User Manual

Version 5.4.0

***I**ntegrated **M**odel for the **P**robabiliatic **A**ssessment of **C**ontaminant **T**ransport*

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INTRODUCTION

1.1 What is IMPACT?

IMPACT is a customizable tool that allows the user to assess the transport and fate of contaminants through a user-specified environment. It also enables the quantification of human and non-human exposure to those environmental contaminants, and the calculation of associated dose. It can calculate the concentration of any contaminant in a range of media, as well as calculate radiation dose and carcinogenic risk or toxic hazard quotients for humans and other biota. IMPACT 5.4.0 has also given focused consideration to the determination of derived release limits (DRLs) for radioactive contaminants. The graphical user interface (GUI) features make it possible to create or modify scenarios quickly and without the need to change the programming code. Thus, users can construct complex models to simulate the impact of contaminant releases in a wide variety of natural environments without the need for programming skills or the use of multiple and complex model interfaces.

1.2 IMPACT for Derived Release Limits

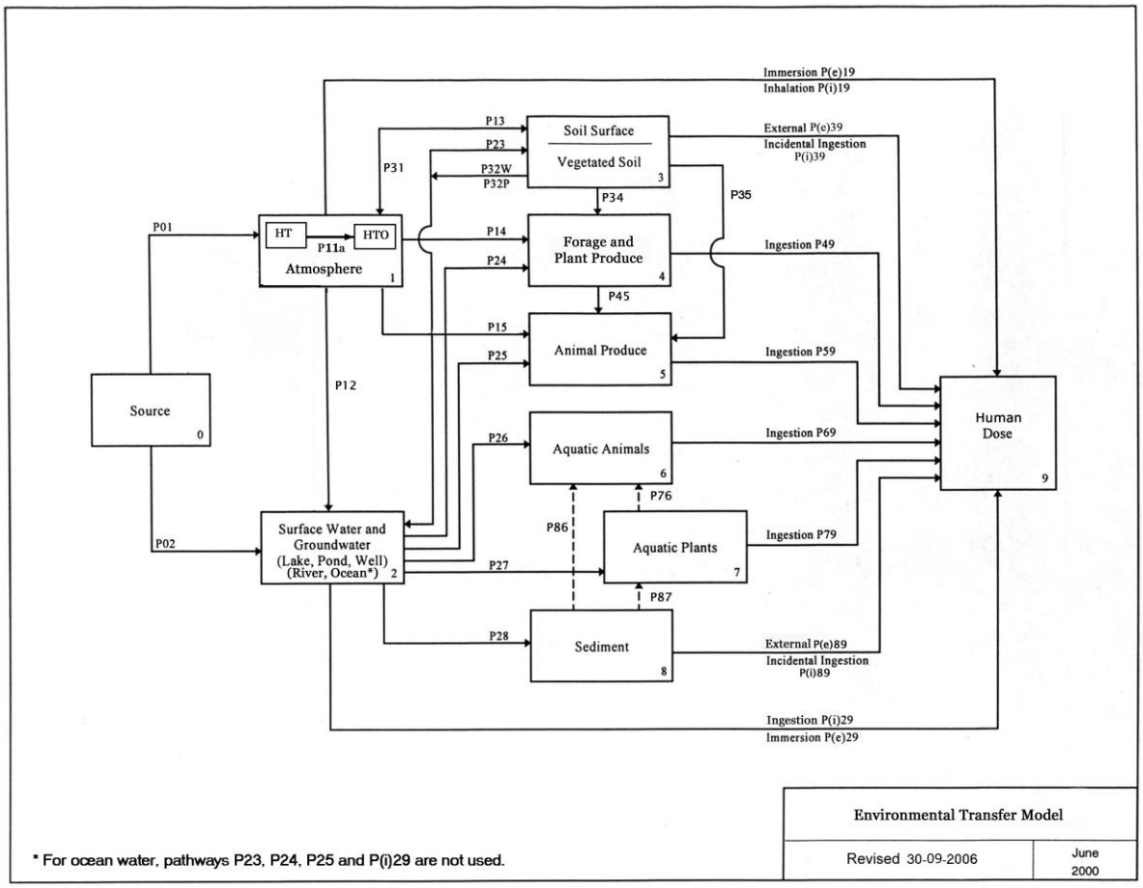
The current version of IMPACT (5.4.0) has been constructed to enable the calculation of Derived Release Limits (DRLs) in accordance with the CANDU Owners Group DRL Guidance Document (EcoMetrix/COG, 2008) and CSA standard N288.1-08. That Guidance Document represents a state of the art understanding of radionuclide fate and transport and human dosimetry and is broadly applicable to all CANDU nuclear facilities in Canada, as well as most instances of radionuclide release and exposure world-wide. The theory and equations embodied in IMPACT are documented in the DRL guidance document (EcoMetrix/COG, 2008) and CSA standard N288.1-08.

Earlier versions of IMPACT (4.0 and 4.x releases) have used non-steady state solutions to contaminant transport equations. These generally arrive at a steady-state consistent with the results of this module (IMPACT 5.4.0). However, this module contains only steady-state solutions, as described in the DRL Guidance document.

1.2.1 Calculation of Concentrations and Doses

Pathway analysis can be represented as a series of contaminant transfers between environmental compartments (Figure 1.2.1).

Figure 1.2.1 Environmental Transport Model



The radionuclide concentration (or dose) in any receptor compartment j is:

$$X_j = \sum_i P_{ij} X_i$$

where the summation is over all compartments, i, transferring into compartment j. If all the values of P_{ij} are known, then the individual X_js may be calculated for any given release rate X_0.

1.2.2 Calculation of Derived Release Limits (DRLs)

DRLs are calculated independently for releases to air and to surface water. For any particular source, radionuclide and representative person, the DRL is obtained by dividing the dose per unit release (X_9/X_0) into the relevant dose limit. For the purpose of DRL calculation, X_0 can be an arbitrary 1 $Bq \cdot s^{-1}$, which leads to DRLs that also have units of $Bq \cdot s^{-1}$. These may be multiplied by 3.154×10^7 $s \cdot a^{-1}$ to obtain the DRL in $Bq \cdot a^{-1}$.

$$DRL = \frac{annual\ dose\ limit\ (Sv \bullet a^{-1})}{\left[\frac{X_9}{X_0\ (a)}\right](Sv \bullet a^{-1} \bullet Bq^{-1} \bullet s)}$$

Details can be found in Annex B Sample calculations in the CSA standard.

The determination of a derived release limit can be completed in three ways in DRL mode. The first is to use the DRL Monitor specifically designed for this purpose. This approach is limited by the fact that only one contaminant can be addressed in a simulation. This may be time consuming, depending on the number of contaminants of interest. The second method is to use IMPACT's multiple-DRL run function to iterate through all contaminants. It is equivalent to repeatedly running the DRL monitor method for all contaminants. The third method is to use a regular dose monitor to calculate dose for all contaminants, and then externally back-calculate the release limit using the output provided. This method may save time, but it requires the user to be diligent in ensuring that all restrictions and assumptions of release limits are met (e.g. only single sources, the inclusion of decay products or secondary metabolites, etc.). Details of the specific restrictions and considerations in calculating release limits are provided in EcoMetrix/COG (2008). It is strongly recommended that the user be familiar with these issues before attempting to calculate release limits using the latter approach.

1.3 General Approach to IMPACT Modeling

In the simplest sense, IMPACT simulates the transport of contaminants through various environmental media that are represented within a user-defined scenario. Accordingly, the main task of IMPACT modeling is the creation of a *scenario*. A scenario is simply a collection of all data describing the area to be modeled. These data constitute a hierarchy of information that defines the abiotic and biotic media through which the contaminants of concern will travel. Once the characteristics of these media have been defined and the scenario is complete, a *simulation* can be performed. A simulation is simply the process during which IMPACT performs a series of calculations to predict the effect of contaminant releases on the modeled environment. The results of the simulation can be displayed in any of several user-specified formats (files, graphs or maps). This output can be examined on its own, or in conjunction with the results of other simulations in order to assess changes in contaminant concentration in any of the media and resulting doses to specified receptors, arising from contaminant release.

1.4 User Characteristics

IMPACT will be a relatively complex software package that incorporates numerical algorithms from various scientific disciplines related to contaminant transport, exposure and potential human health effects. Users of IMPACT for the purpose of completing radiological dose or DRL calculations should have a general understanding of the contaminant fate and transport processes involved, as well as specific understanding of human dosimetry. Familiarity with COG standards for dose/DRL calculation, specifically the DRL Guidance Document (Ecometrix/COG, 2008), and familiarity with the operations and surroundings of facilities of interest is required. The software is subject to user limitations, in that the results (output values) may depend on the setting of time steps or the specification of input parameters.

The Users Manual and the DRL Guidance Document should be reviewed prior to use of IMPACT and should be available during use.

1.5 New Changes in Version 5.4.0

This new IMPACT version 5.4.0 is consistent with DRL Guidance (EcoMetrix/COG, 2008) and CSA standard N288.1-08. The algorithm related changes and bug fixes made between version 5.2.2 and version 5.4.0 are as follows:

- Some parameters changed from embedded values to input parameters, e.g. air plume stability parameters (S) for buoyant restoring acceleration.
- Creation of two washout ratios (Wr): one for washout to plants and one for washout to soil or pond.
- Changes to sector-averaging algorithms for finite cloud dose model, and provision of a switch between finite cloud and semi-infinite model.
- Changes in plant to animal transfer algorithm to accommodate use of dry weight feed intakes.
- Change in air to animal transfer algorithm for HTO, OBT and C-14.
- Creation of two water occupancy factors (OF_w): one for well water and one for lake or river water.
- Constrain HTO to exist in soil porewater, but not in soil.
- Change in irrigation water to plant algorithm (remove land area).
- Change in dictator sources to allow partitioning from dictated media to other media. e.g. dictated air to soil, plants, wells.
- Change to allow conteminant-specific shielding factors, e.g. different volues for pure beta vs gamma emitters.
- Allowance for sector-specific surface roughness values in the atmosphere model.
- Enhanced summary table format options for output of results
- Addition of GIS coordinates (as well as UTM and Lat/Long) for spatial referencing of polygons.

This release of IMPACT 5.4.0 is back-compatible only to the previous release of IMPACT version of 5.2.2. Scenarios created by any older versions can't be opened by this version. To upgrade those scenarios that were created by older IMPACT versions the user needs to firstly open these scenarios with IMPACT 5.2.2 and save as 5.2.2 version scenarios, and then those new saved scenarios are loadable by this IMPACT version 5.4.0.

1.6 Motes on Alignment with CSA standard (N288.1-08)

Sevaral equations that appear in the N288.1-08 document are either alternative calculations (Eq. 6.10, 6.13) or they explain how an inout parameter Is derived (Eq. 6.12, 6.56, 6.64, 6.74, 7.4) and are not implemented in IMPACT for this reason.,

Equation 6.70 for contaminant transfer from plant to honey Is not implemented as such becausee IMPACT does not includee a honey bee receptor (see section 6.1 for advice on representing a honey bee as a special case of the terrestrial animal model). Eqution 6.71 for contaminant transfer for soil to animal is not implemented as such, becausee IMPACT uses a single combined soil intake for animals, rather than separating food-borne anddirect soil intakes (the user must determine the combined soil intakes as an inout).

Equation 6.21 and 6.22 for progeny ingrowth for are no t Implemented since they are rarely required, IMPACT doesn't allow branching fraction. Users wishing to explicitly track progeny of isomerictransition are advised to assume(conservatively) that all transition are through the metastable state.

1.7 Getting Answers to IMPACT Questions

IMPACT incorporates a vast array of functions, calculations, and parameter information and allows a wide range of user-implemented commands and procedures. Due to the broad scope of IMPACT, it is likely that the user will come up with questions during use of this software. To obtain answers to questions, there are a number of available Help options that the user can easily access. The following sections describe each of the Help options in detail.

1.7.1 IMPACT User Manual

Throughout this User Manual, the Windows version of IMPACT is depicted in screen shots and discussed in the text. While some operating systems may differ in some aspects of the appearance of IMPACT on screen, most of the concepts that are discussed apply equally well to Microsoft Windows 2000 and XP operating systems.

In the text of this manual, words and concepts are highlighted in a distinctive style that indicates their meaning.

- menu, window or dialogue items are referred to in **bold type**;
- concepts that are defined elsewhere in this manual are *highlighted in italics*;
- references to other sections of this manual are underlined.

The User's Manual has been written in order to provide a complete overview of all attributes of the IMPACT software. The material provided has been arranged to allow you to gain familiarity with IMPACT's features and functions in order to utilize the software in an informed and effective manner. To help get it up and running quickly, we recommend that the user read through Chapters 1 to 4. This will minimize the need for back-tracking and associated delays in the processes of creating a scenario, running a simulation, and producing the desired results.

1.7.2 Trouble Shooting and Problem Reporting

In the use of IMPACT software, there may be times when operational error messages are generated, signified by a red circle containing a white "X" (see example below). The software has been designed to allow continuation or termination in the event of any such errors. Clicking "OK" on most error messages will allow the user to continue working with IMPACT, or in some cases will cause the program to terminate.

In the event of failure of normal response, the program can be terminated through conventional methods using the Task Manager of the PC Operating System. If persistent problems cannot be resolved by consulting the User Manual, they can be reported by e-mail to info@ecometrix.ca. EcoMetrix staff can assist on a fee-for-service basis.

1.8 Acknowledgments

The IMPACT Team is:

Programming: Gene Shen, Ted Byers, and Lynda Yates

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Database Development: Alan Burt

Graphics: Mike Kesteven

Documentation: Gene Shen, Don Hart

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External Verification & Validation:

Irv Benovich (OPG), Sohan Chouhan (AECL).

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INSTALLATION

Installing IMPACT is a simple process that can be customized. The following sections outline the procedure for successfully installing IMPACT on your computer.

2.1 Before You Begin

Please read the following sections before you install the IMPACT software on your computer.

2.2 Understanding the Operating System

IMPACT 5.4.0 has been designed for installation and operation on any Windows® operating systems. This manual assumes that the user is familiar with the standard features of the operating system the user is using, whether it is Windows®2000 or XP. Knowledge of fundamental techniques such as clicking and double-clicking, selecting, dragging, and using menus and windows is assumed. If you are unfamiliar with these techniques, we strongly recommend review of the User Manual for your operating system before attempting to use IMPACT.

2.3 System Requirements

IMPACT is a C++ application, therefore it can theoretically run on any operating system. In practice, however, it has only been tested and qualified for Microsoft® Windows 2000 and XP. If you intend to run it on other platforms, contact IMPACT technical support for information on any platform-specific issues you may need to know.

A single installer program for Windows® applications is provided on the IMPACT Installation CD.

The memory and disk space requirements for IMPACT vary for each platform, but generally IMPACT requires a system with 256 to 512 megabytes of RAM (total) and 100 megabytes of free hard disk space for a full installation. As is the case with any numerically intensive application, IMPACT runs best on the fastest processor you can obtain.

Please note that the appearance of IMPACT interface windows might be different between different Windows font settings. Some font settings might cause some contents to be hidden in bottom and right corners. Since IMPACT is not capable of adjusting the opening size of the windows screen setting, the user is advised to use the default Windows operation system font settings.

2.4 Installing IMPACT

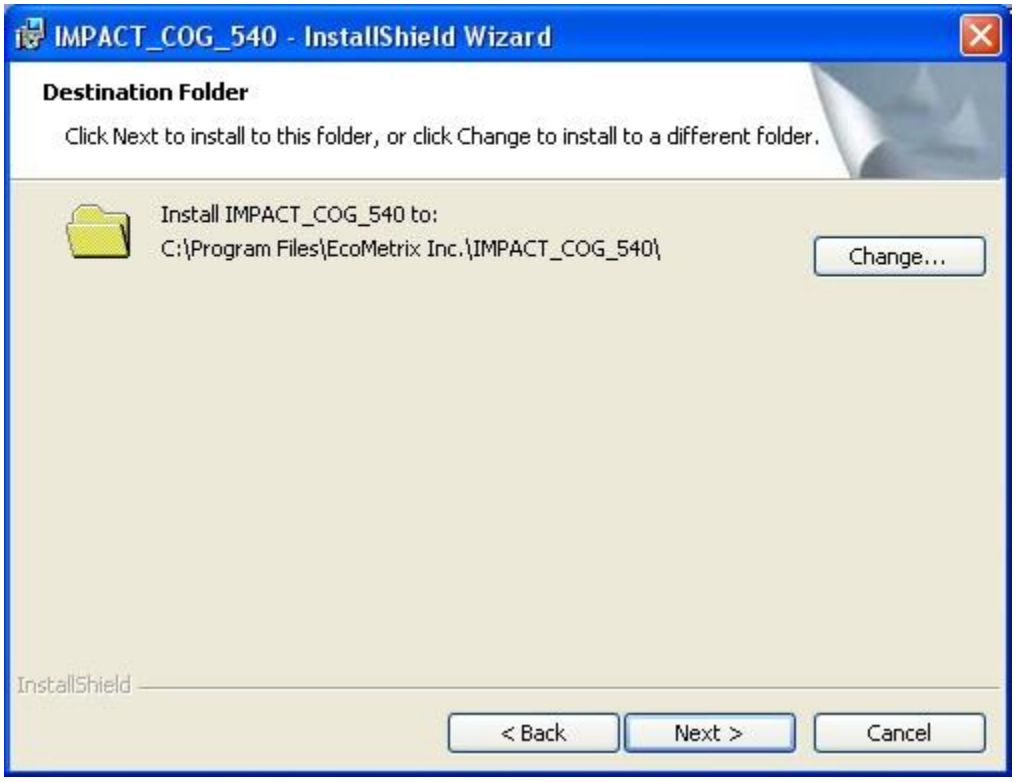
After obtaining the IMPACT CD, you must launch the installer application by double-clicking on the "IMPACT_COG_540_Setup_16Jun2009.exe" application contained on the CD. The ensuing process will install all program files necessary to run IMPACT, as well as an example database and an electronic version of this User Manual. Please note that the installation can be cancelled at any step in the Setup process by simply clicking the "Cancel" button.

Once the installer has been launched, you will be presented with the install start-up screen.

To continue the Installation, simply click "next" to proceed.

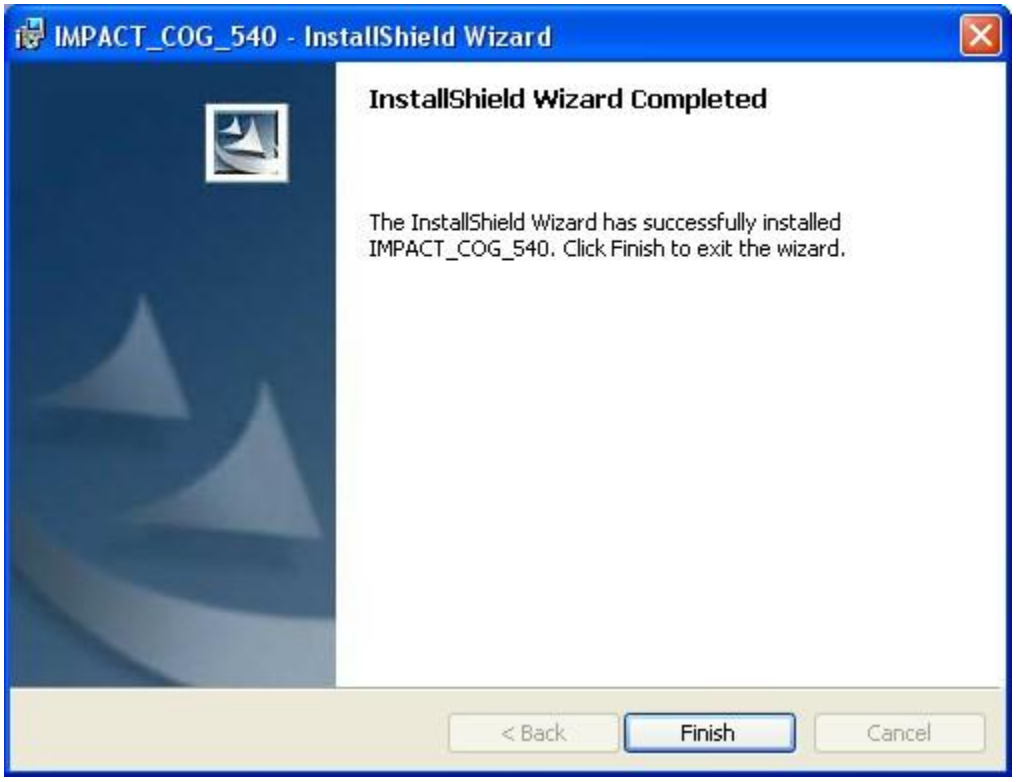
The following window will be needed to fill in user name and organization name. if the installation is only used by the user who intalled IMPACT, then "Only for me" should be checked, otherwise "Everyone who uses this computer (all users)" should be checked.

The next window allows you to specify the installation directory. A default directory will be chosen unless the user specifies otherwise through the "browse" option.



The next step in the installation process is to confirm the setup information that has been provided to this point. If there is any need to cancel the installation process, this can be accomplished by clicking the "Cancel" button to stop the installation.

Once the installation process is complete, a window will appear notifying the user of the successful installation of IMPACT, and requesting the user to "Finish" the setup procedure.



Once this is done, IMPACT will be available for use by clicking on the executable file icon in the destination directory or by clicking on any of the shortcuts established during installation

2.5 Where to Go From Here…

Once IMPACT has been installed and registered, the user should read Chapters 3 and 4 to become familiar with the basic concepts and features that are part of the IMPACT model. After reviewing and understanding the concepts presented in Chapters 3 and 4, it is strongly recommended that the user read Chapter 5, which describes the process of running a simulation and accessing and customizing the results of a completed simulation. Chapter 6 contains descriptions of special cases of IMPACT application that may help the user deal with certain unique situations. Appendix A describes technical aspects of the software that the may be of benefit to understand while using IMPACT

MODEL FEATURES AND FUNCTIONS

3.1 IMPACT Files

The main IMPACT program directory contains several separate files and folders:

- an “IMPACT_COG.exe” file for launching the IMPACT application (double clicking the file icon will start IMPACT);
- 8 support files in the same folder where IMPACT_COG.exe is located. These files are: ModelBase.bin, rtl100.bpl, tee7100.bpl, vcl100.bpl, vclx100.bpl, CC3280MT.DLL, BORLNDMM.DLL;
- a "Data" folder containing all ".bin" files comprising the default database (21 files in total; data files for each of the 15 block classes, a data file for contaminants, a data file for global reactions, a data file for references, a data file for scenario version, a data file for windrose data format and a default windrose file);
- an “icons” folder that contains all user-defined icons (used in creating "blocks", as described in Section 4). The user can add any number of custom icons to the “icons” folder if desired;
- folders for any Scenarios that the user creates or any output generated by using IMPACT. These are only default locations added at the time of installation, and the user may save scenarios or model output to any location.

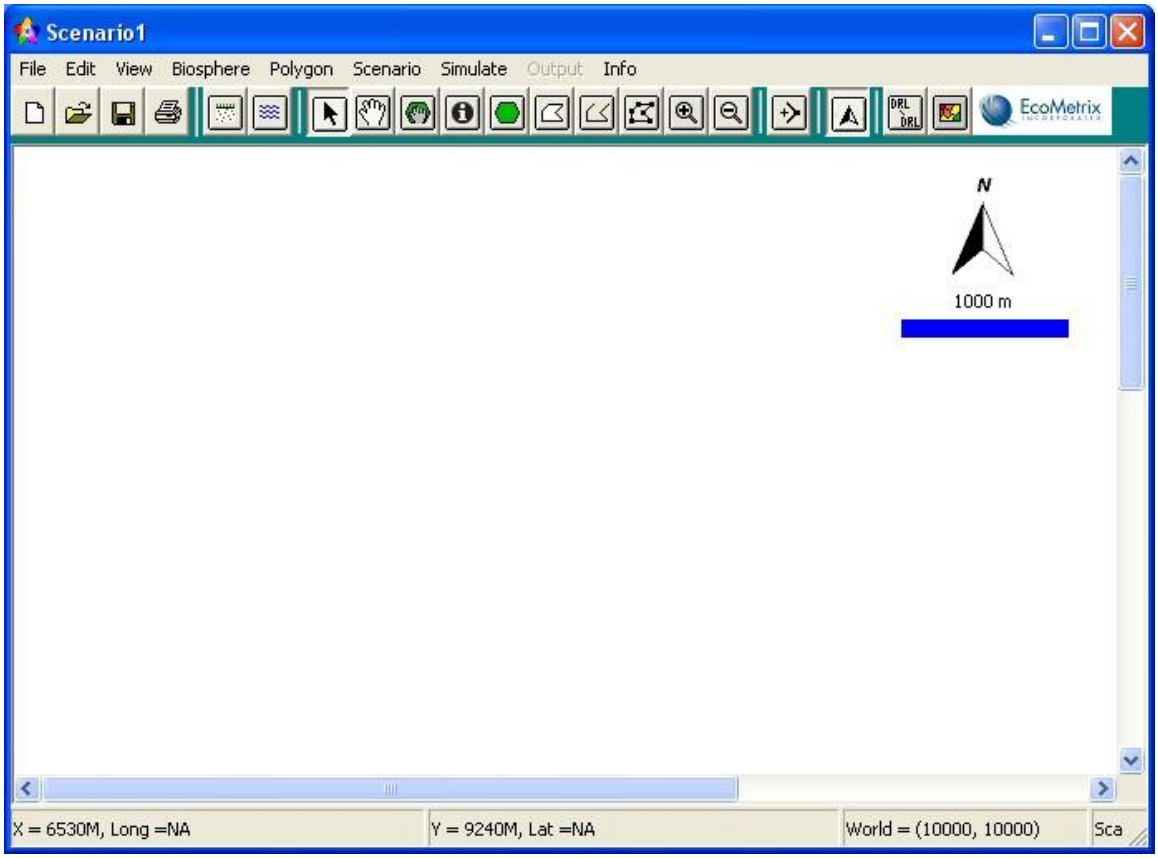
The installed folder is: "C:\Program Files\EcoMetrix Inc\ IMPACT_COG_540\".

When creating scenarios or running a simulation, IMPACT generates different types of files. *Scenario* files contain all of the data that describe the scenario which is being modeled (see definition and discussion in Section 3.3.2). This is the group of files that is created when you choose **Save…** from the **File** menu in the main Window. Each distinct scenario created by a user will be comprised of a ".SNR" file (referred to specifically as the "scenario" file) and the Data folder, all located in a unique directory of the users choosing. The data folder will hold the same list of files in the main Data folder in the IMPACT directory (see description on previous page). For the specific scenario, the Data folder will contain files that are specific to that scenario, and may contain a site-specific windrose (rather than the default) and also a site-specific background image file, if one has been imported into the scenario.

Output files are created when you run a simulation. They contain the results of the model calculations in a format which the user specifies in the **Run** dialogue in the **Simulate** menu (refer to Chapter 5 for a discussion of generating results). When a scenario is created, IMPACT automatically creates an output folder in the user-designated directory selected for the scenario. The user can then instruct IMPACT to direct all output files to that directory, or sub-directories therein.

3.2 Starting IMPACT

The IMPACT application is started by double-clicking the "IMPACT_COG.exe" file. When IMPACT first starts, it creates a blank scenario file ("Scenario 1"). It also calls the data files (".bin" files) in the "Data" folder in the main IMPACT folder and uses these as the "database" for the scenario. The initial screen represents the Biosphere Window (see Section 3.4.1), and appears as follows:

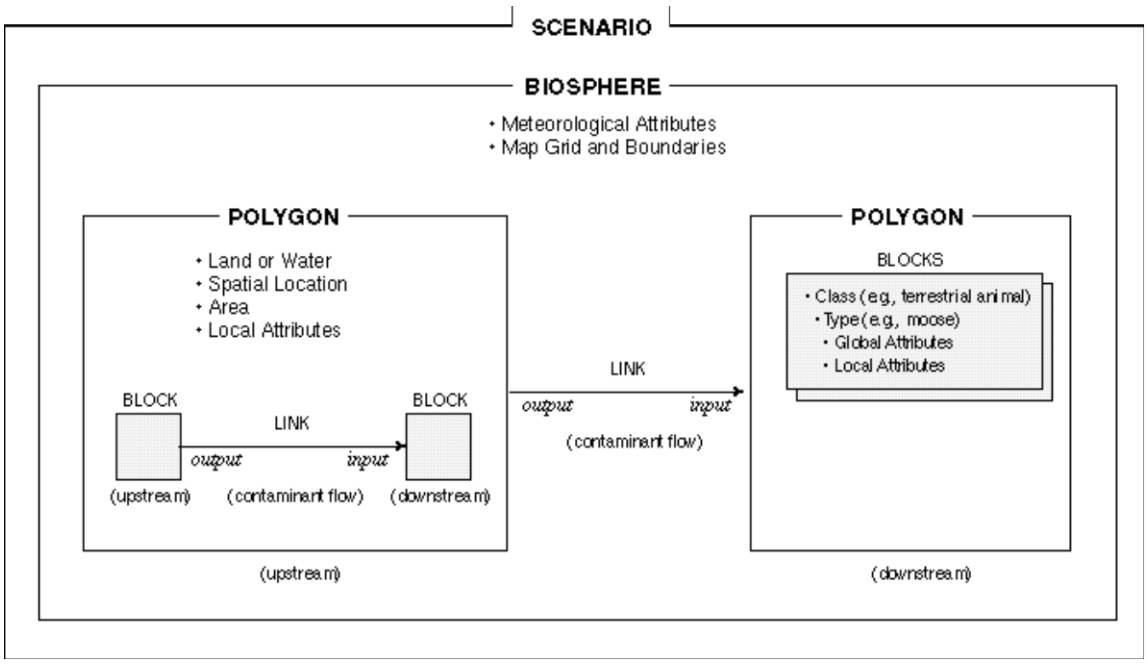


At this point, the user can begin to create a new scenario or chose to open existing scenarios using the **Open** command in the **File** pull down menu. IMPACT scenario files can be saved by using the **Save** command in the **File** menu, typical of most Windows ® applications. Saving the current scenario can also be accomplished using the Save button (💾) In the Toolbar.

3.3 Basic Concepts

Prior to actually running IMPACT, the user should have an understanding of a number of concepts that together form the basis of the model and its capacity to simulate contaminant transport in multi-media environments. This section of the manual provides an overview of each of these key concepts.

The following diagram illustrates the associated hierarchy and the interconnectedness of a number of the concepts discussed in this section.



Each of these concepts is discussed separately below.

3.3.1 Modelling

A *model* is simply a representation of any given feature and/or process, or collection thereof. The features and processes may be physical, chemical or biological. IMPACT models the collective features and processes that make up the environment (both natural and man-made) by creating a *scenario* which encompasses a number of *polygons* and *blocks* representing environmental features (e.g. soil, water, air, plants, animals and humans) and the contaminants of concern. IMPACT incorporates various equations that mathematically represent the processes responsible for contaminant transport through the represented media during each *simulation* that is run.

3.3.2 Scenario

In the simplest sense, a *scenario* is simply a collection of all data describing the situation to be modeled. It is composed of a well-defined, connected sequence of features, events and processes. This includes all *polygons* and *blocks* that have been created by the user. These data define both the physical (e.g. size, topography, and meteorology) and biological (e.g. animals and plants) characteristics of the area. All the data describing a given scenario are saved to an IMPACT scenario file when you choose the **Save** command from the **File** menu or use the Save button command in the Toolbar.

3.3.3 Simulations

A *simulation* is simply the process during which IMPACT performs a series of calculations to predict the effect of contaminant releases on the modeled environment (represented by a given *scenario*.) The period of time over which a simulation is run is divided into a number of time steps of user-specified length. Each *simulation* can also be run for one or more *iterations*, where each iteration provides one of the possible results of the series of calculations, assuming that there is some variability in the input and that the modeling process is *probabilistic*. Chapter 5 provides a detailed discussion of the processes of running a *simulation*.

3.3.4 Polygons

Polygons represent two-dimensional areas of the Earth's surface with generally uniform characteristics. The two basic polygon types are *Land* and *Surface Water*. These two polygon types are used to represent all possible combinations of surface features in the area that is to be represented in the model. Every polygon has two *attributes* that define its spatial extent within the modeled area:

1. a centroid point, with an X and Y coordinate. The X and Y coordinates can be in Cartesian system or in UTM system;
2. a surface area.

Additional user-specified *attributes* describe physical features of the polygons, such as water depth and flow rate (*Surface Water* polygons). Section 4.7 introduces the process of creating polygons within a scenario.

3.3.5 Blocks

Each *polygon* may contain one or more *blocks*, representing environmental media or receptors within the polygon where contaminants may accumulate. Blocks may represent a variety of media or receptors, including soil, air, sediment, animals, plants and various types of humans (e.g. adults, children, or infants). Blocks are defined by both their *class* and their *type*.

Blocks are represented by distinctive user-selected icons that serve to graphically depict the block when constructing a scenario. The user can create and add any custom icon to the "Icons" folder in the main IMPACT folder. There is no restriction on the number of polygons or blocks that can be created in a scenario. The user can create as simple or complex a scenario as desired.

Most blocks do not have a spatial reference point themselves. Instead, they are assumed to reside at the centroid of the polygon in which they are located. Section 4.8 describes the process of creating blocks within polygons.

3.3.6 Class

Each *block* belongs to a specific *class* (as defined in the "Database") that broadly defines which element of the environment the block represents. Examples of block classes are *Human*, *Terrestrial Animal*, *Soil*, and *Pond*. Within each class are one or more *types* that further define the characteristics of a block. This classification system is analogous to the scientific binomial classification of biological organisms, where the first name represents the more general classification of genus (analogous to the block's *class*) and the second name denotes the species (analogous to the block's *type*).

As an example, a block representing the *Terrestrial Animal class* could be characterized by the *type* "Cow", "Pig", "Goat", or "Chicken". There are a fixed number of block *classes* within IMPACT - the user cannot add or delete *classes*. The user can create as many different *types* within each *class* as required or desired.

3.3.7 Type

Block *types* further define the characteristics of a block of a given *class*. Block *types* are important to recognize during creation of a scenario since *global attributes* specified in the database apply to all blocks of the same *type*.

3.3.8 Attributes

Characteristics of *polygons* and *blocks* are described using attributes, which can be quantifiable numbers, discrete values or pointers to other data items. All attributes can contain a reference to a data source, whether that source is a scientific journal article or a ballpark estimate.

There are two kinds of attributes in IMPACT: *global* attributes and *local* attributes. *Global* attributes describe a characteristic that is common to all blocks of the same *type*. For example, the inhalation rate parameter for the *Terrestrial Animal* type "Cow" is a global attribute. The value assigned to this attribute is assumed to apply to all blocks of type "Cow" in the scenario (i.e., all cows within a scenario are assumed to respire at the same rate).

If there were two different types of Cow (e.g. the calf and adult cow) with different inhalation rates, the user would have to create two Cow *types* in the database ("Cow Adult" and "Calf", as an example). Global attributes are specified in the *Database* window (refer to Section 3.4.7) and are fully discussed in Section 4.6 (Creating a Database).

Because of the shared nature of global attributes, you must be careful when modifying them. If you change the value of a global attribute, you are changing it for every block of the same type within the scenario.

Local attributes are specific to individual blocks. When you change a local attribute you are changing it only for the selected block and it affects only that block in that location. Local attributes are typically used to represent characteristics that vary from block to block, even though the blocks may be of a common type. An example of a local attribute is the depth of a well (represented using *Groundwater* blocks). Even though several *Groundwater* blocks may share common global attributes such as porosity or bulk density, each *Groundwater* block will have a unique depth. Local attributes are specified in any of a series of *Attribute* windows (refer to Section 3.4.4).

3.3.9 Aliases

An *Alias* block simply serves as a placeholder for another block in certain situations, analogous to a *shortcut icon* in Windows®. An *Alias* block is used as a liaison in creating *links* between the block it represents and a block(s) which is located in different polygon. Aliases are used in IMPACT to create links between media found in different locations (e.g. links between an urban resident and food products originating from a rural farm, or between those same residents and sand and water at a regional swimming beach). The process of creating an alias block is described fully in Section 4.8.16.

3.3.10 Pathways and Links

Polygons and *blocks* can often have more than one input or output, indicating that they receive or discharge contaminants to or from more than one polygon or block along different *pathways*. The transfer of contaminants from one polygon or block to another is specified by creating a *pathway* or *link* between them. IMPACT depicts links on-screen by drawing a line between the two blocks with an arrow pointing to the receiving block (i.e. in the direction of contaminant transfer).

Links can represent different processes of contaminant transfer, depending on the context. A link between a plant (upstream) and animal block (downstream) represents ingestion, while a link between two lake polygons represents flow of water. Some links can represent more than one process, such as a *Water* to *Human* link which can represent both ingestion and dermal exposure pathways (swimming or bathing). Section 4.10 describes the procedure for creating links and also identifies the conceptual processes that links between specified block classes represent.

3.3.11 Probabilistic

In some instances, the exact value of a parameter is not known, but a range of possible values, each with a certain probability of occurrence, has been defined. IMPACT has the capacity to represent this uncertainty. Most attributes can be defined *probabilistically* - i.e., as distributions as opposed to single fixed values (as discussed in Section 4.6.3). When a *simulation* is run *probabilistically*, IMPACT completes a user-specified number of iterations (replications) of the simulation. Each successive *iteration* of a given *simulation* will complete calculations by selecting (based on the probability of occurrence) one of the possible input values of *parameters* that have been defined in a probabilistic manner within the scenario. Accordingly, the output from *probabilistic simulations* consists of a range of values produced during each iteration. The output is described using several statistical quantities such as mean, maximum, minimum, and percentile.

3.3.12 Data Storage

All the *polygons*, *blocks*, and *attributes* defined in a *scenario* are saved to a single IMPACT file. The default scenario is an "empty" scenario in that it contains no polygons or blocks. It is supplied as a template that can be used as a starting point for creating a new scenario. Once you start to create polygons and blocks, you should save the scenario under a new name.

3.4 Windows

The IMPACT model uses a number of windows to provide access to different model components. The means of access, the contents, and the specific operational features of each of the available windows are described in detail in this section of the manual.

3.4.1 Biosphere Window

Access

The main window in IMPACT is the *Biosphere* Window. This window is the main window where the contents of a scenario are displayed. This window is opened whenever you create a new scenario or open an existing scenario. Simply click within the bounds of this window to bring it to the foreground or close all other IMPACT windows.

The Biosphere window also contains the main menu bar and toolbar that are used to create and modify a scenario, including commands for creating and modifying polygons. It remains open at all times while IMPACT is running.

Summary of Functions:

- create or modify polygons
- link polygons
- use as a gateway to all other IMPACT windows
- print contents (in list, graphic, or map display mode)
- import or export graphic files

Contents and Features

The Main window contains seven menus and one toolbar. All windows that are available in IMPACT, and their associated commands. are accessible through the Biosphere window's pull-down menu bar. Each menu contains commands that pertain to a certain type of function:

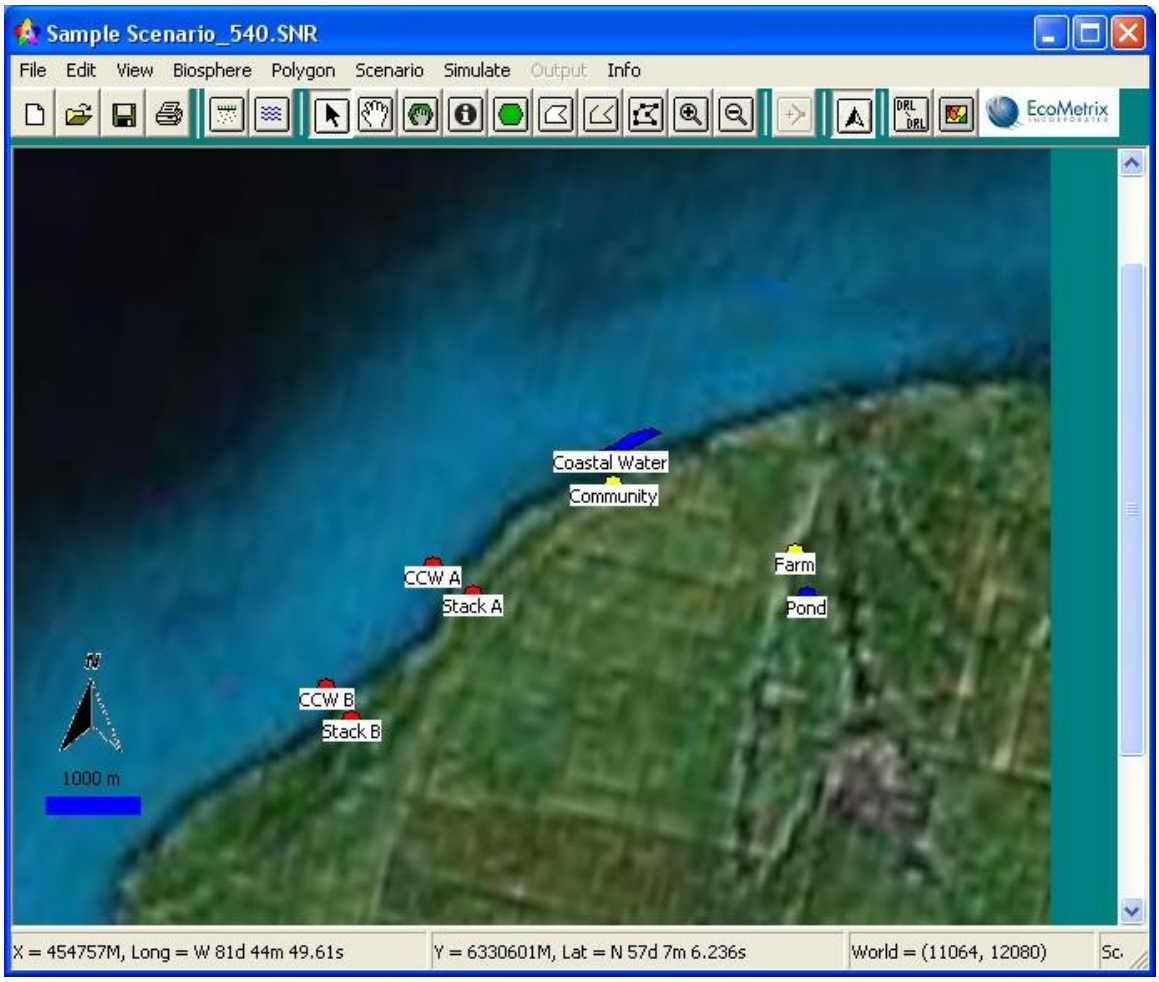
- **File**: commands for creating, opening, closing, saving and printing of scenarios;
- **Edit**: commands for copying and pasting objects;
- **View**: commands for changing how information is displayed in a window;
- **Biosphere**: commands for changing attributes of the Biosphere, such as scale, meteorology, etc.
- **Polygon**: commands for creating and changing attributes of Polygons;
- **Simulate**: commands for starting a simulation and controlling the type of simulation output desired;
- **Info**: commands for displaying the program version.

The functions of the main toolbar (depicted below) are described in Section 3.5. The activation of toolbar commands result in changes in cursor appearance to help track the current command mode.

This window is called *Biosphere* since it provides a visual depiction of the base components of the biosphere (i.e. land and water) and provides access to all attributes of the biosphere. All polygons that have been created for a scenario are displayed in this window. There are two ways of viewing contents of the *Biosphere* window:

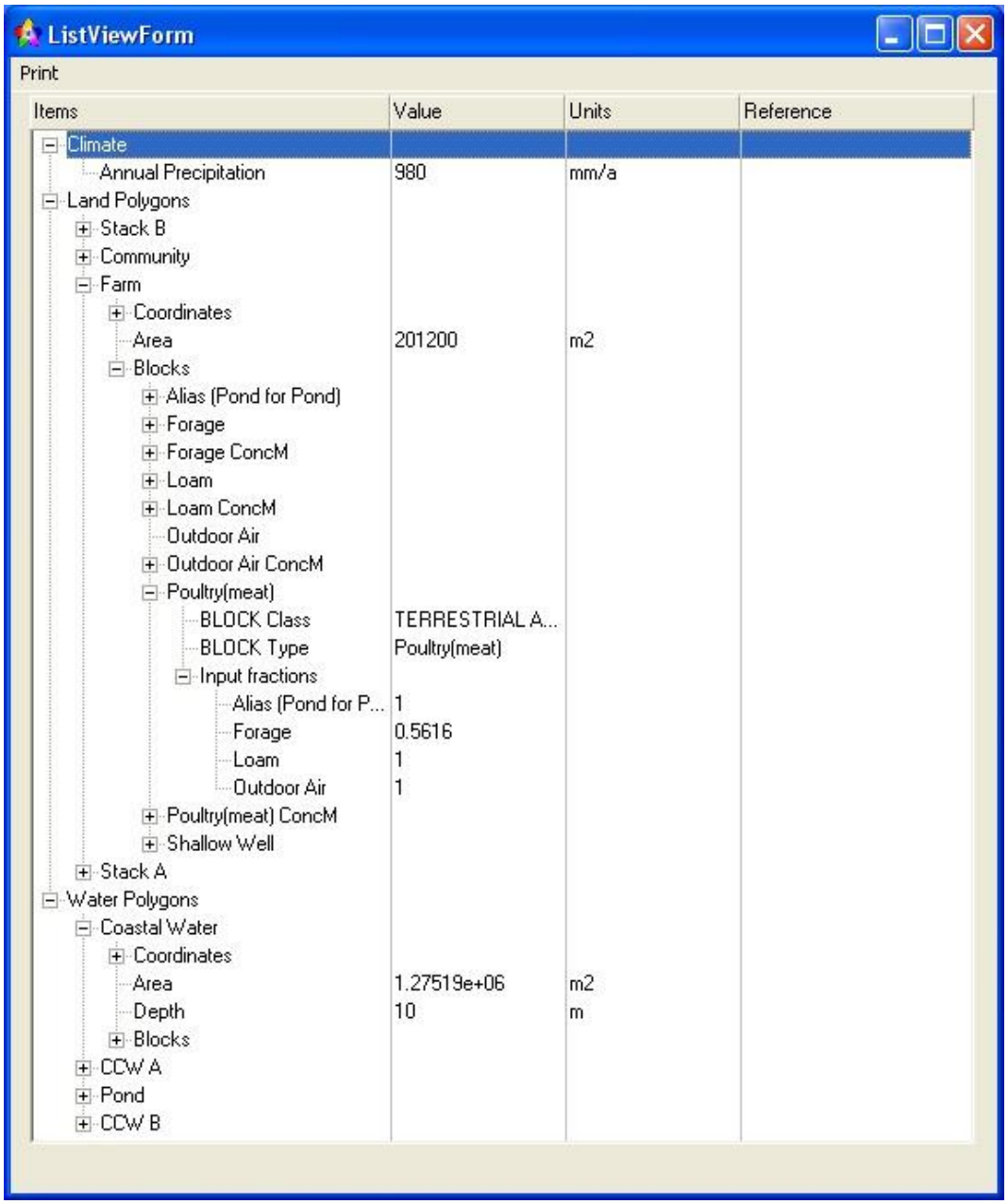
1. **Graphic mode**; all polygons are drawn with their true outlines (as in graphic mode) superimposed on a background map image which the user can import as a graphics file of various formats (refer

to Section 4.2 and 4.3.2). This is the default mode and is the one in which the user can interact with the Biosphere.



In Graphic mode, the status panel in the bottom part of the window shows the current map scale, coordinates the cursor is over, and the current grid spacing. In the example shown above, the map scale is 1 : 67338, the cursor is over the point (UTM: 454757, 6330601; Lat: 57d7m6.236s, Long: -81d44m49.61s) and the biosphere boundaries are 11064 m by 12080 m.

2. **List view mode**; scenario contents are provided in text summary format within an expandable menu list, an example of which is provided below. List for is for review and presentation purposes only, and modifications of scenario content are not permitted.



Printing in graphic mode is accomplished by selecting the **Print** command from the **File** menu or by clicking the **Print** button (). The list view window contains its own print command button In the top left corner (see above).

The total area occupied by any scenario is defined by the biosphere's map boundary, which may be specified within the *Scale* dialogue (refer to Section 3.6.4). Depending on the map boundary and current scale, the usable area of the *Biosphere* window may be much larger than the area visible on screen. In this

case, you can use the scroll bars to move to different parts of the map or use the **Zoom In** and **Zoom Out** toolbar buttons to increase or decrease the scale at which polygons are drawn.

The name of the scenario file that is currently open is shown in the *Biosphere* window's title frame, located at the top-left of the window. In the example provided above, the file name is *Sample Scenario_540.SNR*. This will change if you choose to save the file under a different name.

3.4.3 Polygon Contents Window

Access

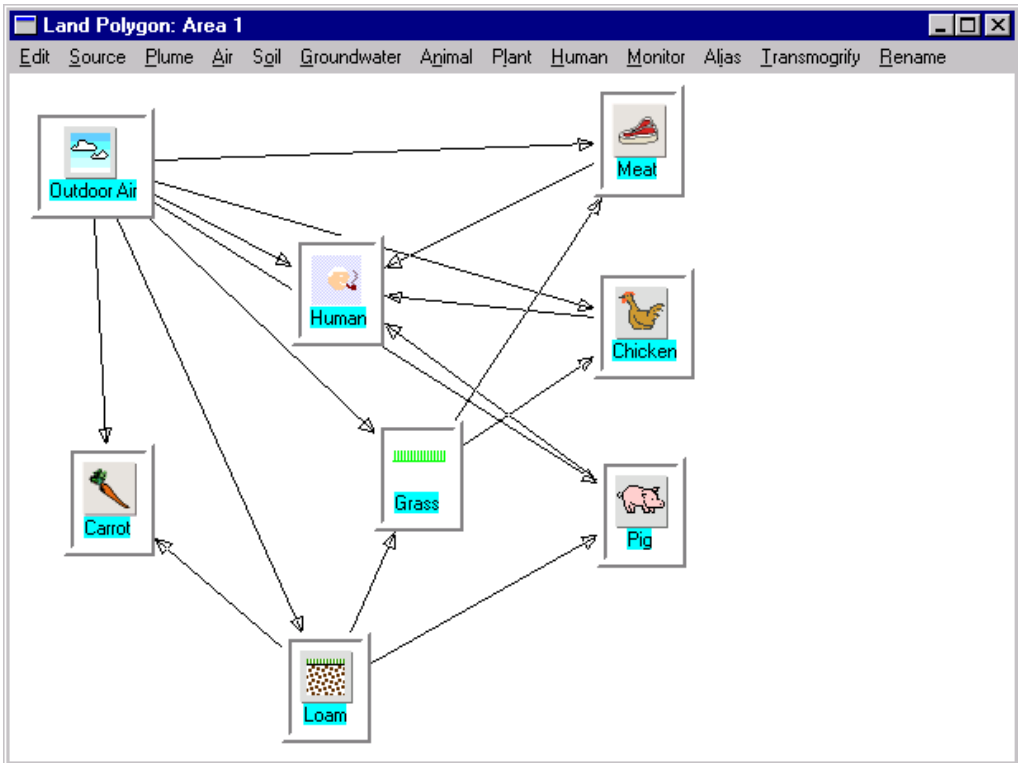
While in the *Biosphere* window, the user can open any polygon's *Contents* window by double-clicking on the polygon, or by selecting the polygon (single click) and choosing the **Open** polygon command from the **Polygon** pull-down menu.

Summary of Functions

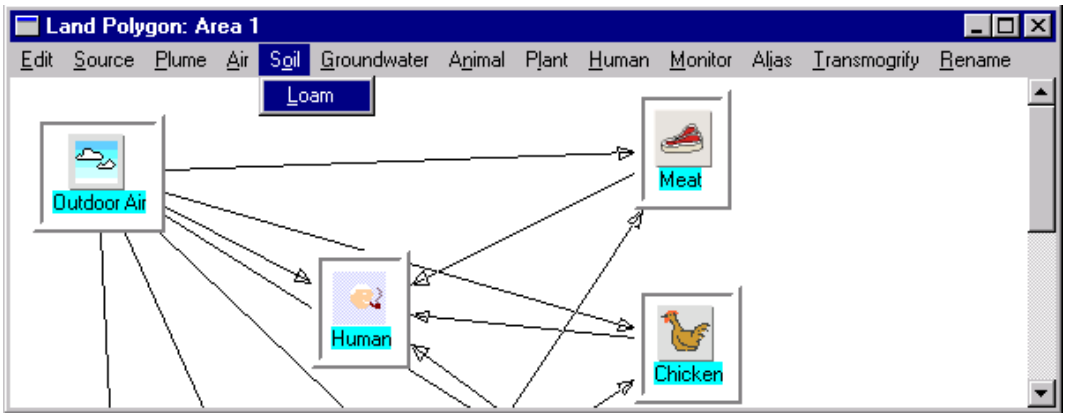
- create or modify blocks
- create aliases
- create links between blocks

Contents and Features

Each polygon appearing in the *Biosphere* window has its own associated window in which the contents of that polygon are displayed. The window's name is set by default to "Land Polygon" or "Water Polygon", followed by "<polygon name>", (e.g. Land Polygon: "Area 1" in the example shown below). The polygon name is defined by the user as an attribute of the polygon itself (refer to Section 4.7.3 for discussion of polygon attributes).

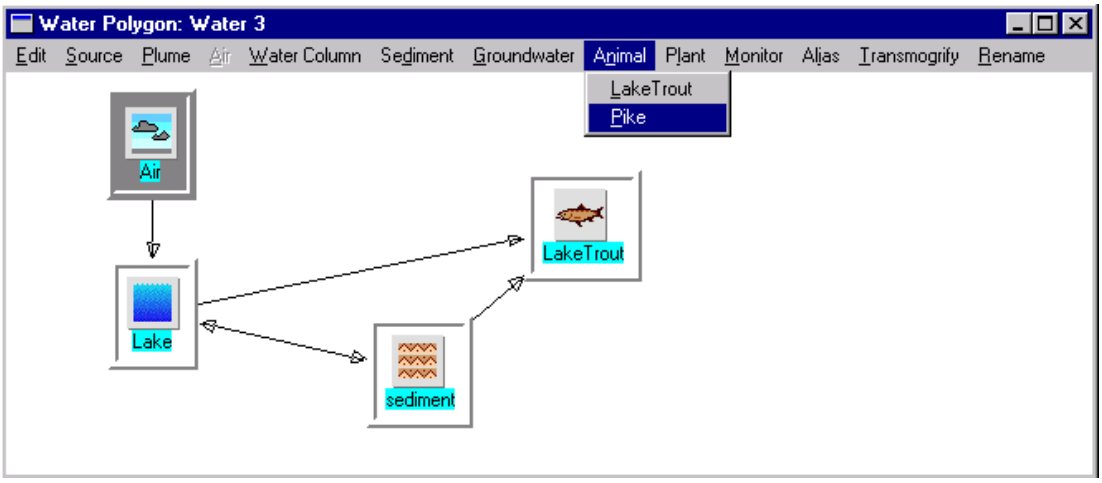


When a polygon's *Contents* window is open, the user can create blocks that will reside within that polygon by using the command menus appearing at the top of the polygon window. The user creates blocks by selecting a block type from the appropriate menu (e.g., creating the block of Type *Loam* from the pull down menu for the Class *Soil*, as shown below).



Land and Water polygons each have distinct series of *Block* pull down menus, restricting the types of blocks that can be created in either type of polygon. For example, various aquatic block items (e.g. fish, Pond, sediment) are only available within a *Water* polygon's window, and terrestrial block items (e.g. *Terrestrial*

Animal, *Terrestrial Plant*) are only available when a *Land* polygon window is open. The available block menus in Land polygons can be seen in the preceding illustration. Water polygon pull-down menus are depicted below.



For further detailed instructions regarding the creation of blocks, refer to Section 4.8.

3.4.4 Attribute Windows

Access

To open the *Attribute* window for any polygon, select the Attributes button from the toolbar menu (ICON) and then select (single click) the polygon of interest. To open the *Attribute* window for any block within a polygon, simply double click on the block of interest.

Summary of Functions

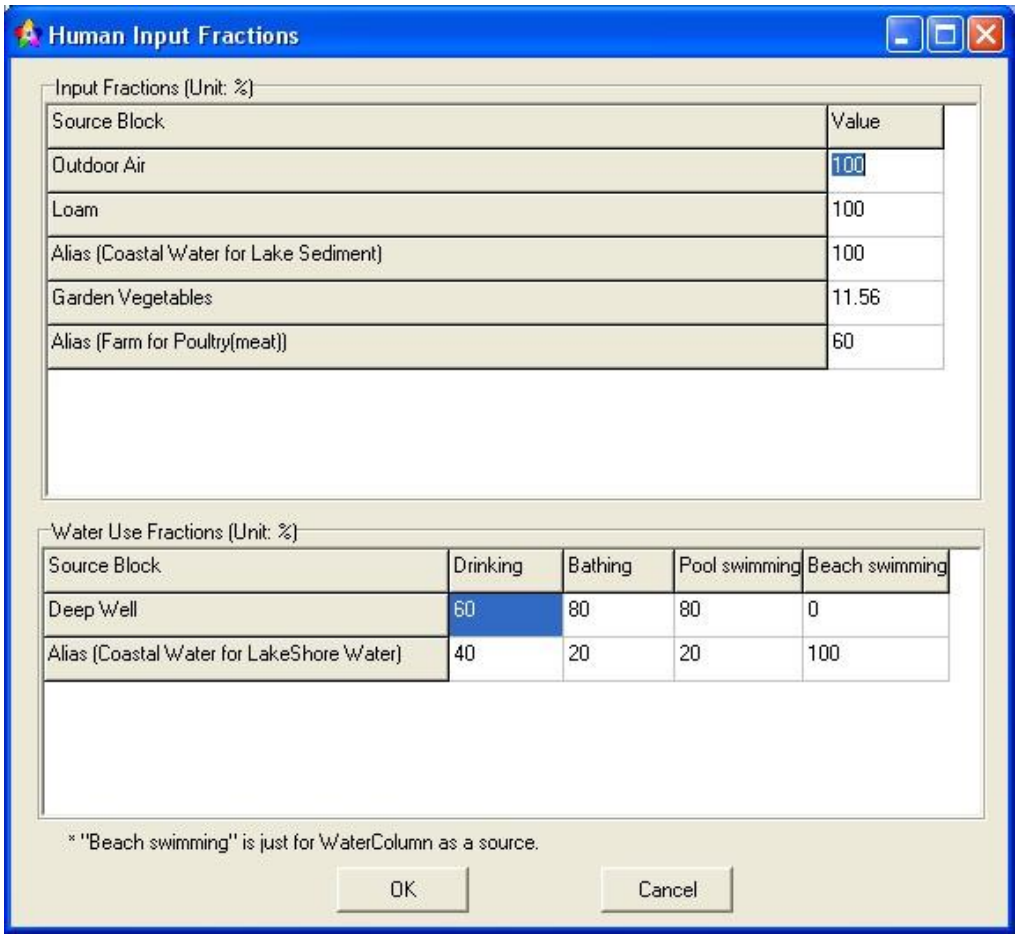
- define attributes of polygons
- define local attributes of blocks
- specify input fractions for blocks
- specify output fractions for polygons

Contents and Features

The *Attribute* window contains a list of all *local* attributes that belong to a block or polygon. *Global* attributes for a given block are accessed in the *Database* window (refer to Section 3.4.7). For clarification of the difference between *global* and *local* attributes, refer to Section 3.3.8.

In the following example, the attributes of the block *Human Adult (Area 1)* are shown. Most blocks have an *Input fractions* attribute, which shows the relative contribution from blocks that are linked to the block in question. In this example above, the *Human Adult (Area 1)* block has seven input blocks. Input fractions

show the percentage of air, soil, sediment, terrestrial plant food, terrestrial animal food Intakes that comes from each source block. Water use fractions show the percentage of each water use that comes from each source block.



3.4.5 Contaminants Window

Access

The *Contaminants* window can be opened by choosing **Contaminants**… from the **Biosphere** pull-down-menu.

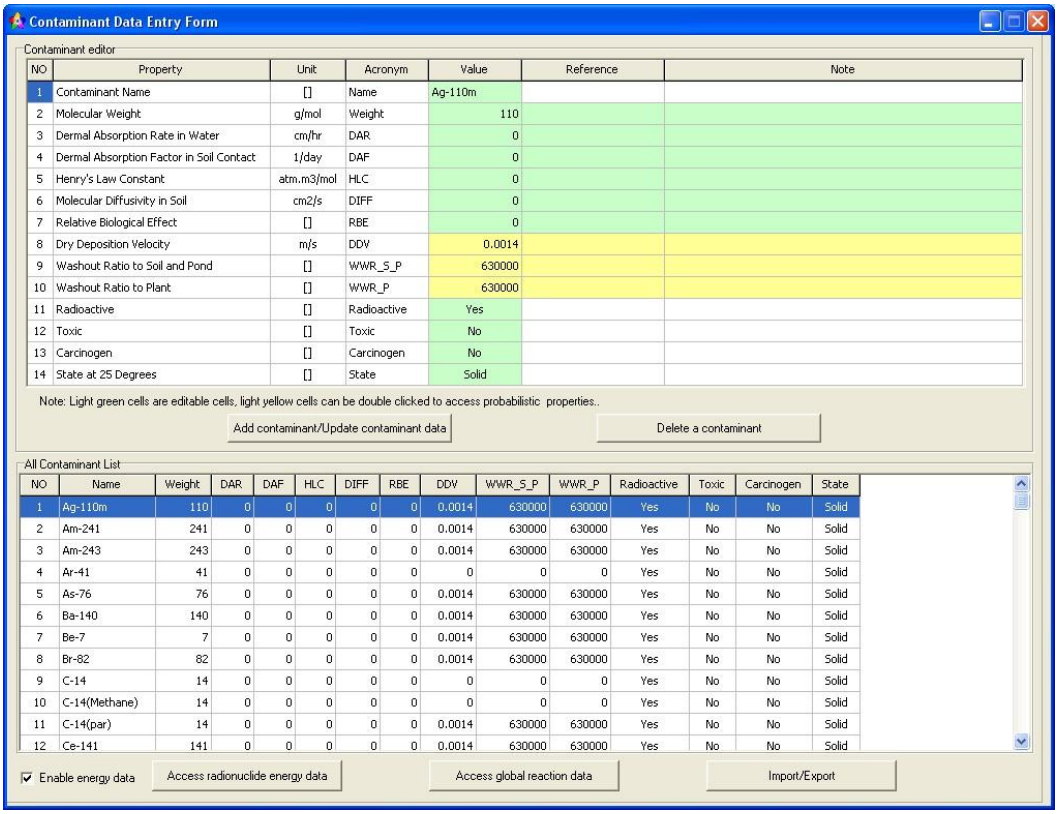
Summary of Functions

- define contaminants
- specify global attributes of contaminants

- import *Excel* files
- export *Excel* files

Contents and Features

The *Contaminants* window allows the user to review and modify the list of contaminants available for assessment within the active scenario, and defines various global attributes that affect the behaviour of those contaminants in the environment. The user can also use the **Global Reactions** command to specify decay functions of any given contaminant. Other parameters that affect the environmental fate and transport of contaminants are mediated through the *Database* as contaminant-specific attributes of various *Types* in the *Database* (refer to Section 4.6).



NO	Property	Unit	Acronym	Value	Reference	Note
1	Contaminant Name	[]	Name	Ag-110m		
2	Molecular Weight	g/mol	Weight	110		
3	Dermal Absorption Rate in Water	cm/hr	DAR	0		
4	Dermal Absorption Factor in Soil Contact	1/day	DAF	0		
5	Henry's Law Constant	atm.m3/mol	HLC	0		
6	Molecular Diffusivity in Soil	cm2/s	DIFF	0		
7	Relative Biological Effect	[]	RBE	0		
8	Dry Deposition Velocity	m/s	DDV	0.0014		
9	Washout Ratio to Soil and Pond	[]	WWR_S_P	630000		
10	Washout Ratio to Plant	[]	WWR_P	630000		
11	Radioactive	[]	Radioactive	Yes		
12	Toxic	[]	Toxic	No		
13	Carcinogen	[]	Carcinogen	No		
14	State at 25 Degrees	[]	State	Solid		

NO	Name	Weight	DAR	DAF	HLC	DIFF	RBE	DDV	WWR_S_P	WWR_P	Radioactive	Toxic	Carcinogen	State
1	Ag-110m	110	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
2	Am-241	241	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
3	Am-243	243	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
4	Ar-41	41	0	0	0	0	0	0	0	0	Yes	No	No	Solid
5	As-76	76	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
6	Ba-140	140	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
7	Be-7	7	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
8	Br-82	82	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
9	C-14	14	0	0	0	0	0	0	0	0	Yes	No	No	Solid
10	C-14(Methane)	14	0	0	0	0	0	0	0	0	Yes	No	No	Solid
11	C-14(par)	14	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
12	Ce-141	141	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid

The **Contaminant editor** table is for the active contaminant that is selected currently. The user can modify the attributes of this contaminant. The modified attributes need to be saved by hitting a button labeled **Add contaminant/Update contaminant**.

Light green cells in the **Contaminant editor** table are editable and light yellow cells can be set for probabilistic attributes by double-clicking those cells.

The **All contaminant list** table shows summarized contaminant attributes. This table can be exported and imported from/to an excel spreadsheet by clicking **Import/Export** button. Note that the export and import function doesn't carry all the probabilistic attributes between IMPACT and excel spreadsheets.

Access radionuclide energy data provides a way to access the radionuclide energy data that will be used in the finite-cloud human dose model. The check box **Energy data** switches the model to be the semi-infinite model when it is unchecked or the finite-cloud model when it is checked.

VARIOUS CONTAMINANT ATTRIBUTES ARE NOT RELEVANT AND THEREFORE NOT DEFINED IN DRL MODE.

3.4.6 Global Reactions Window

Access

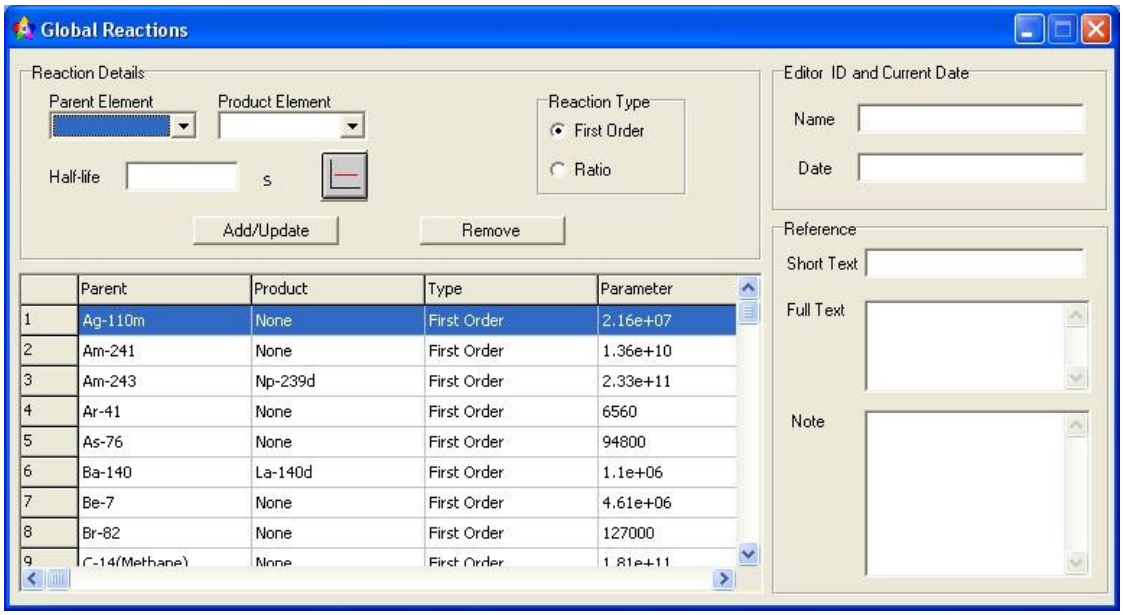
The *Global Reactions* window can be opened by choosing **Global Reactions**… from the **Biosphere** pull-down-menu. It can also be accessed by clicking the relevant command button (i.e., Access Global Reactions Data) in the *Contaminants* window (see example above).

Summary of Functions

- defines radioactive decay functions (half-life, progeny)

Contents and Features

The Global Reactions window allows the user to define the radioactive half-life and specify the progeny (if any) of each radionuclide in the database.



3.4.7 Global Radiation Energy Input Window

Access

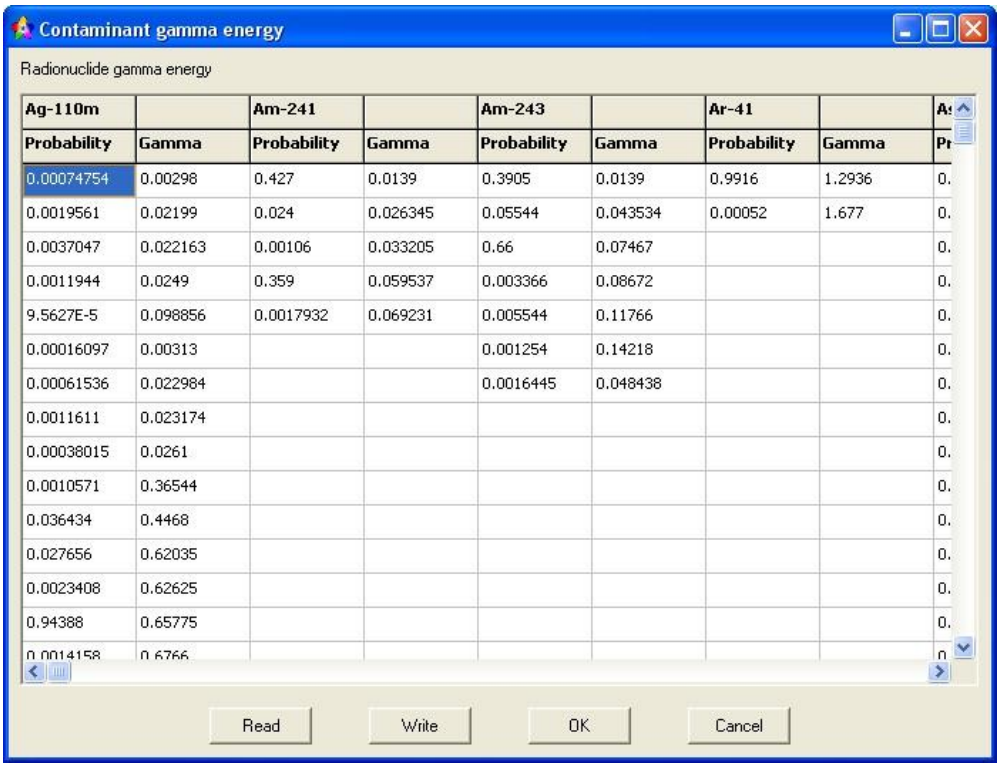
The *Global Radiation Energy Input* window can be opened by choosing **Access Radionuclide Energy Data** from the **Contaminant window** (see example above).

Summary of Functions

- defines radionuclide emission probability and gamma energy

Contents and Features

The Global Radiation Energy Input window allows the user to define the emission probability and the energy of gamma emission in the database. The energy data can be input directly or read from a excel spreadsheet.



Ag-110m		Am-241		Am-243		Ar-41		As
Probability	Gamma	Probability	Gamma	Probability	Gamma	Probability	Gamma	Pr
0.00074754	0.00298	0.427	0.0139	0.3905	0.0139	0.9916	1.2936	0.
0.0019561	0.02199	0.024	0.026345	0.05544	0.043534	0.00052	1.677	0.
0.0037047	0.022163	0.00106	0.033205	0.66	0.07467			0.
0.0011944	0.0249	0.359	0.059537	0.003366	0.08672			0.
9.5627E-5	0.098856	0.0017932	0.069231	0.005544	0.11766			0.
0.00016097	0.00313			0.001254	0.14218			0.
0.00061536	0.022984			0.0016445	0.048438			0.
0.0011611	0.023174							0.
0.00038015	0.0261							0.
0.0010571	0.36544							0.
0.036434	0.4468							0.
0.027656	0.62035							0.
0.0023408	0.62625							0.
0.94388	0.65775							0.
0.0014158	0.6766							0

3.4.8 Database Window

Access

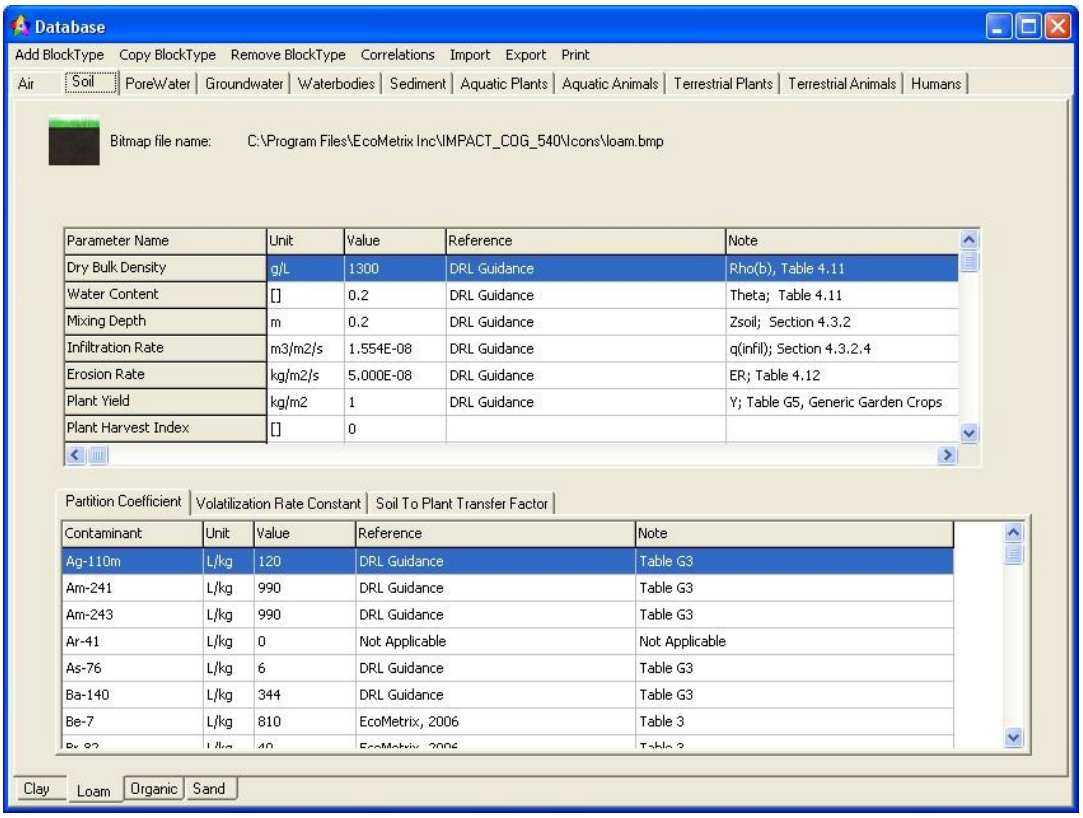
The *Database* window can be opened by choosing **Database**… from the **Biosphere** menu.

Summary of Functions

- specify global attributes
- define block types
- import *Excel* files
- export *Excel* files

Contents and Features

All *global* attributes are shown in the *Database* window. These attributes are grouped according to the *class* to which they apply (e.g. *Soil*, *Terrestrial Animal*, *Human*, etc.). Each class is represented by a data group that can be accessed simply by selecting the appropriate tab at the top of the window. The types contained in each *class* are identified as tabs along the bottom of the window. The example below shows a *Database* window with the *Soil* class selected to illustrate attributes of this particular class. The *Loam* type has been selected to reveal the list of global attributes that the user can specify. Global attributes that are contaminant-specific are themselves organized in groups, each accessible through a tab. In the following example, the contaminant-specific attribute of *Partition coefficient* has been selected for display and/or editing.



VARIOUS DATABASE ATTRIBUTES ARE NOT DEFINED IN DRL MODE. CERTAIN TABS ARE NOT AVAILABLE AND CERTAIN ATTRIBUTES (IDENTIFIED AS **NA***) CANNOT BE ACCESSED.*

Note that any changes to global attributes of a given block type within the *Database* window will apply the changes to all individual blocks of that type within the scenario. Refer to Section 4.8 for a discussion of the procedures for specifying global attributes of block types.

3.4.8 Messages Window

Access

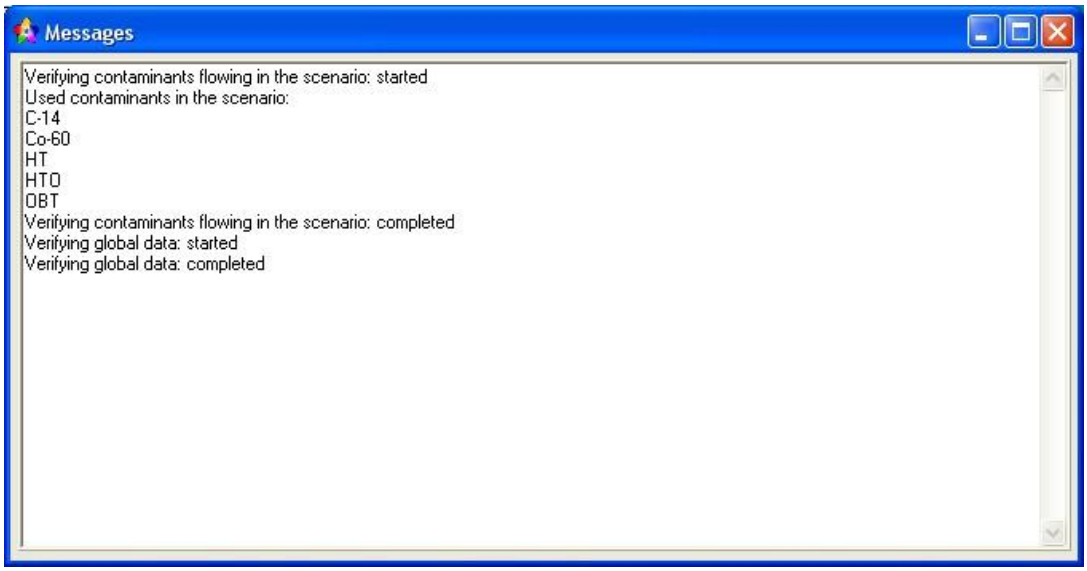
The **Messages** window is automatically displayed at the beginning of a simulation (i.e. following the **Run…** command In the **Simulate** pull-down menu). It is also displayed as a result of selecting the **Verify…**command in the same menu.

Summary of Functions

- copy text to the clipboard
- print contents of window

Contents and Features

Any messages that are generated during a simulation or verification are displayed in the *Messages* window (see example provided below). The text in this window can printed directly or copied (Ctrl + C) and pasted into any text file, but cannot be directly modified.



Messages displayed in the *Messages* window can be of two basic types:

1. verification messages that contain information that may be useful. For example, IMPACT posts an information message informing the user of the list of radionuclides that are active In the scenario
2. error messages that inform the user that an error has occurred which may require immediate attention. For example, if a database value has not been defined, or has been defined with inappropriate values, an error message will be posted listing that parameter.

3.4.9 References Window

Access

This window can be opened by choosing **References** from the **Biosphere** menu.

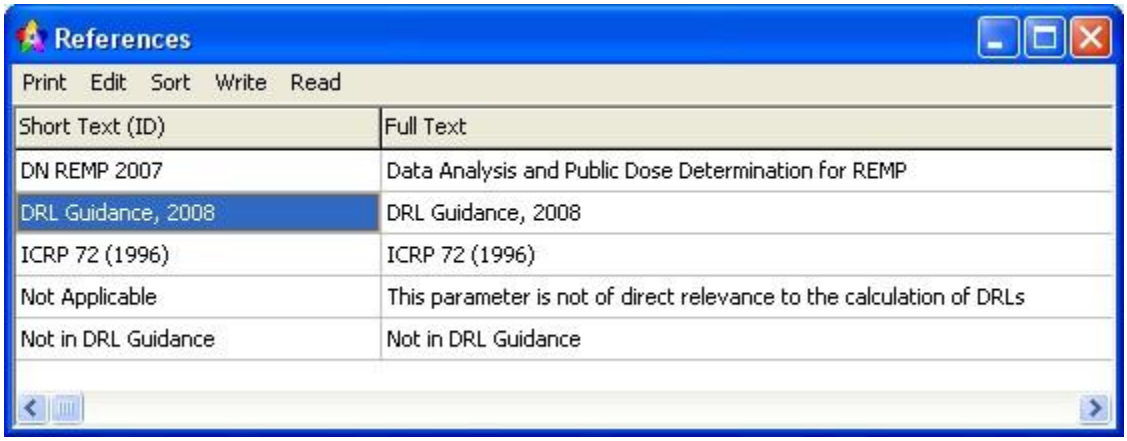
Summary of Functions

- define references

- modify existing references

Contents and Features

Any attributes that have been defined in the Database, the Contaminants window, and the Global Reactions window can have a reference attached to them. Parameters in various other dialogues (primarily those identified with the symbol) can also be referenced. Before the user can assign a reference to an attribute, the reference must first be defined in the *References* window. All the references that have been incorporated in any given scenario are displayed in the *References* window.



Each reference has a long form and short form. The short form is displayed in the Reference pop-up menu in various attribute dialogues. The long form is used for display and documenting purposes. In the *References* window, the long form is truncated for display purposes (the full set of characters are retained).

A full description of all processes related to creating or modifying references is provided in Section 4.4.

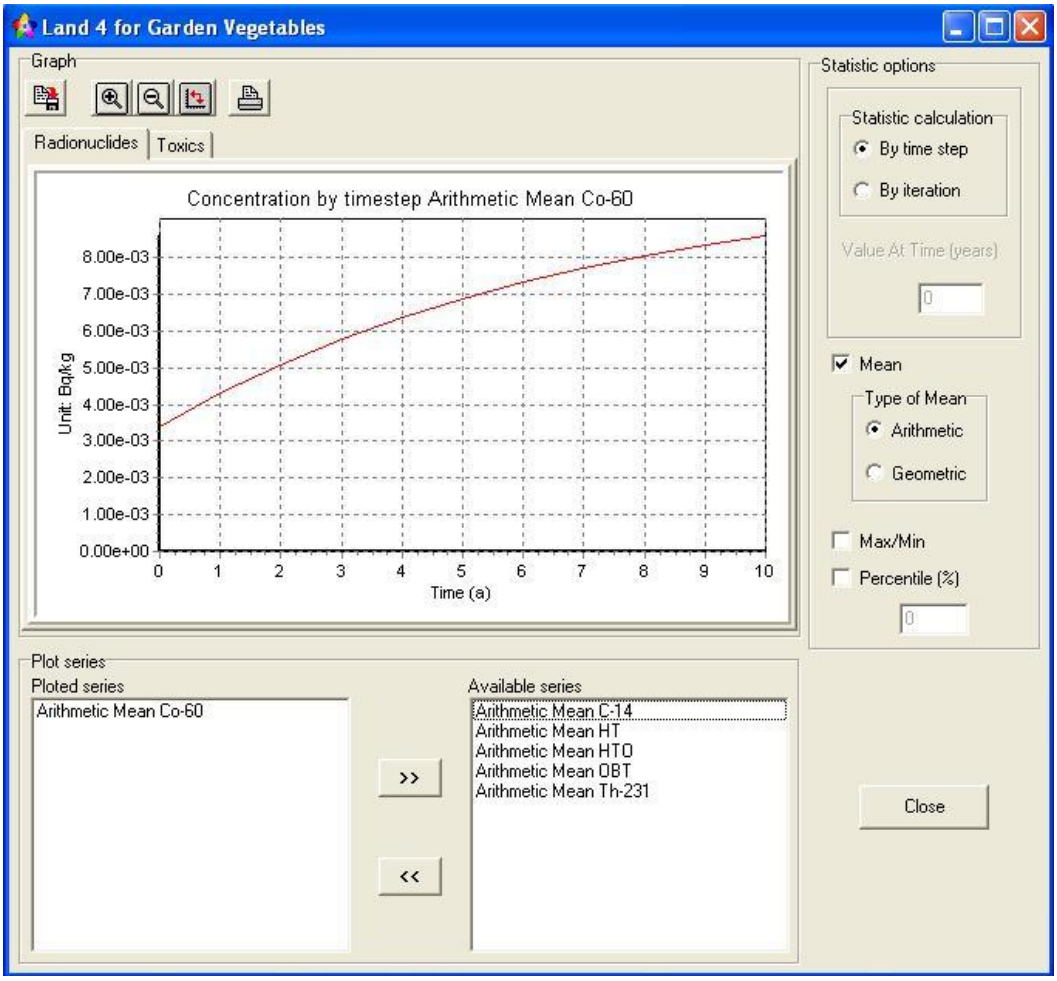
3.4.10 Graphic Analyses Windows

Access

A *Graphic Analyses* window is opened when a monitor has been selected to proceed with graphic analyses after a simulation is complete.

Summary of Functions

- view or print results in graph format
- manipulate scale and axes of graph display
- save graphs to graphical image files



The process of doing graphs is fully described in Section 5.5.2.

3.5 Toolbars

The various windows in IMPACT contain *Toolbars* consisting of command buttons that perform some common functions, as described in the following table. The final column in this table indicates the window(s) for which the specified Toolbar buttons are enabled.

Icon	Name	Function	Enabled in…
	Create new document	Creates a new, untitled document.	All
	Open existing document	Opens an existing document that the user specifies.	All
	Save current document	Saves the contents of the current scenario to a file, prompting the user for a name if it is a new	All
	Print contents of active window	Prints the contents of the active window. Same as choosing **Print…** from the File menu.	All
	Land Polygon Mode	Switch to land polygon mode.	Biosphere

	Water Polygon Mode	Switch to water polygon mode.	Biosphere
	Selection Tool	Select polygon(s) – single click Open Polygon(s) – double click	Biosphere
	Pan Tool	Move the background image	Biosphere
	Polygon Move Tool	Drag polygon(s) to new locations.	Biosphere
	Zoom In Tool	Zoom in to on-screen image centre by a factor of 2 when tool button is clicked	Biosphere
	Zoom Out Tool	Zoom out from on-screen image centre by a factor of 2 when tool button is clicked	Biosphere
	Info Tool	Open attribute window of a polygon by clicking on it.	Biosphere
	Generic Polygon Tool	Create a default 8-sided polygon (land or water).	Biosphere
	Closed Polygon Tool	Create a closed polygon by digitizing.	Biosphere
	Open Polygon Tool	Create an open polygon by digitizing.	Biosphere
	Polygon Edit Tool	Edit the individual points in a polygon.	Biosphere
	Polygon Edit Tool	Insert a point to a polygon	Biosphere
	Compass and Scale bar	Show north direction and distance of 1000 meters	Biosphere
	Multiple DRL run mode	Set the run model to multiple DRL run	Biosphere
	Isopleth Run Mode Tool	Switch to Isopleth run mode	Biosphere

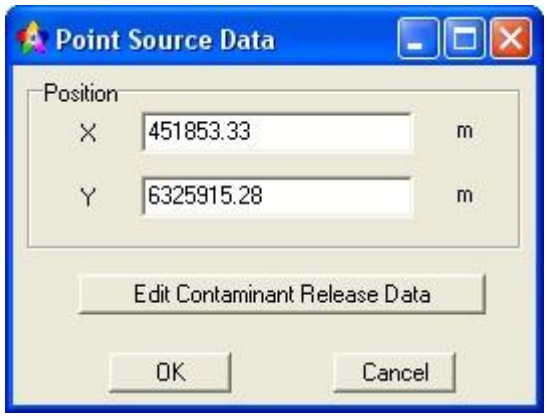
3.6 Dialogues

IMPACT contains numerous interactive dialogues that open at various points in the modeling process. Some of these dialogues require simple responses while others may necessitate more complex user interaction. This section contains brief descriptions of those dialogues that require a greater level of user feedback. Detailed descriptions of these and other dialogues and their use in creating or modifying IMPACT scenarios are provided in Chapter 4.

3.6.1 Source Dialogue

Access

A *Source* dialogue is opened first by double clicking on a *Source* block's icon (e.g. *Dictator* source, *Point* source, *Groundwater* source) within a polygon window. This will open the *Attribute* window (see example provided below) for the selected source. In this window, the user may specify the coordinates of the source, which are initially set equivalent to the coordinates of the polygon in which the source is located. To define or modify the contaminant data associated with the source, simply click on the *Edit Contaminants Release Data* box to open the *Source Contaminants* dialogue.

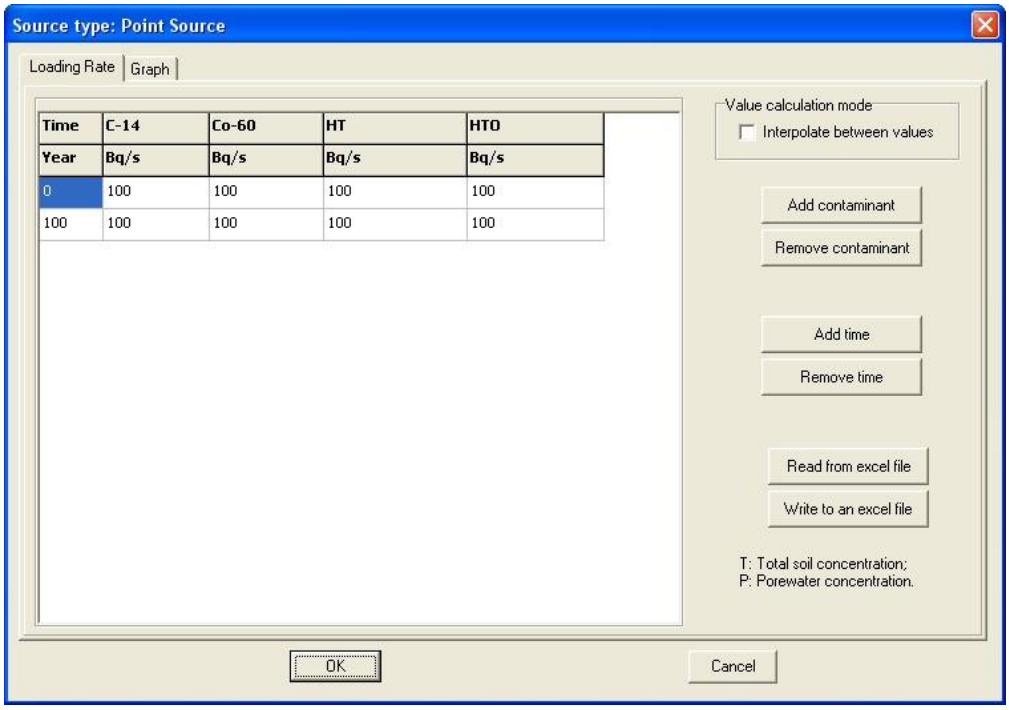

Point Source Data
Position
X
451853.33
m
Y
6325915.28
m
Edit Contaminant Release Data
OK
Cancel

Summary of Functions

- define or modify contaminant source terms for Point, Groundwater, Pond, or Dictator sources

Contents and Features

All of the characteristics defining the release of a contaminant from the source are specified in the *Source* dialogue:



IMPACT defines the source releases using tabular data, this table consists of time, contaminants and loading rates. Section 4.8.14 provides a detailed explanation of using the *Source* dialogue in the process of defining the release of a contaminant.

MULTIPLE CONTAMINANT SOURCE PHASES ARE NOT PERMITTED IN DRL MODE. A SINGLE CONSTANT VALUE SHOULD BE DEFINED FOR THE DURATION OF CONTAMINANT RELEASE.

3.6.2 Baseline Inflow Dialogue

Access

The *Baseline Inflow* dialogue is contained within the water polygon attributes window, which itself is accessed by selecting the **Attributes** tool button and clicking on any water polygon (refer to Section 3.3.4).

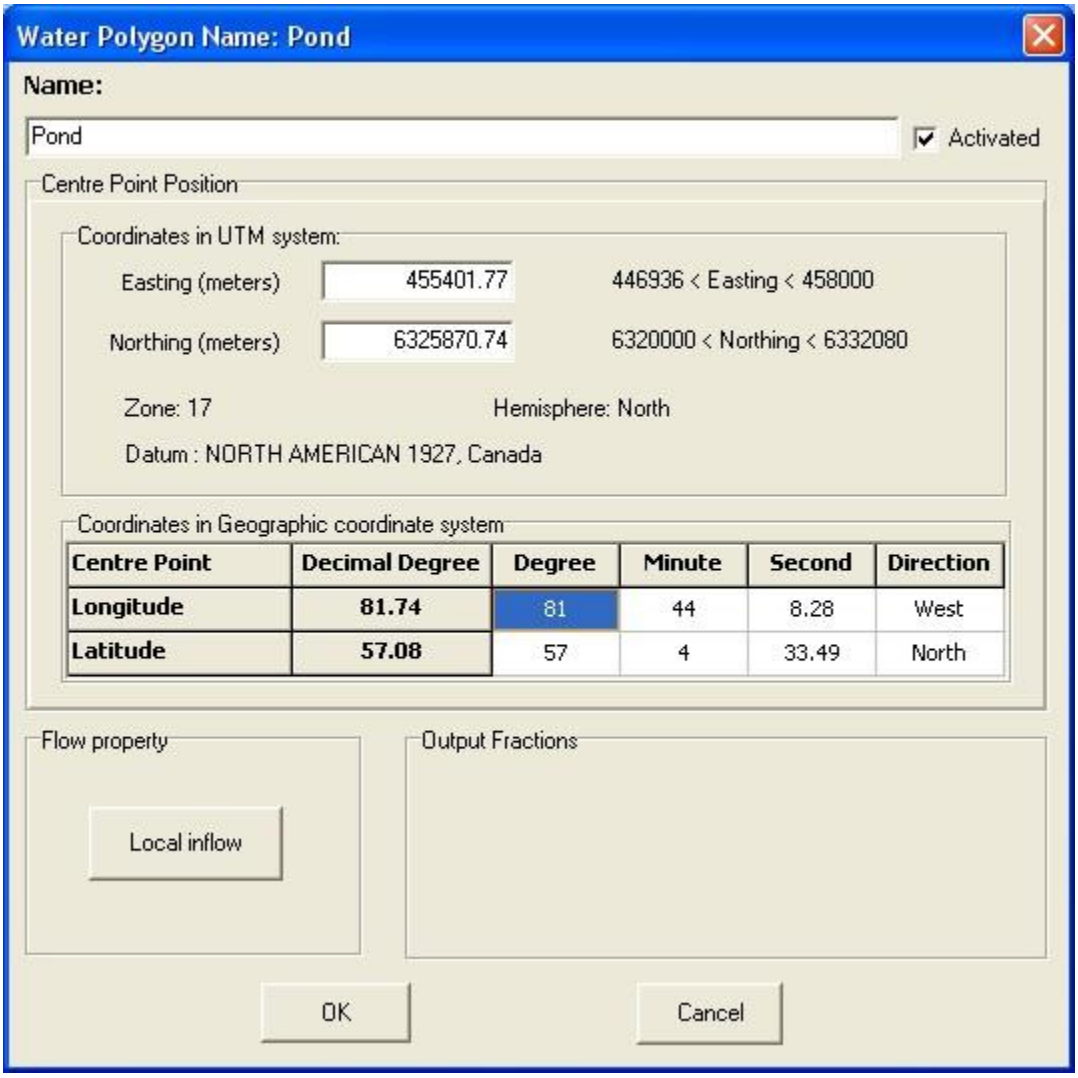
Summary of Functions

- define baseline inflow rate for water polygons

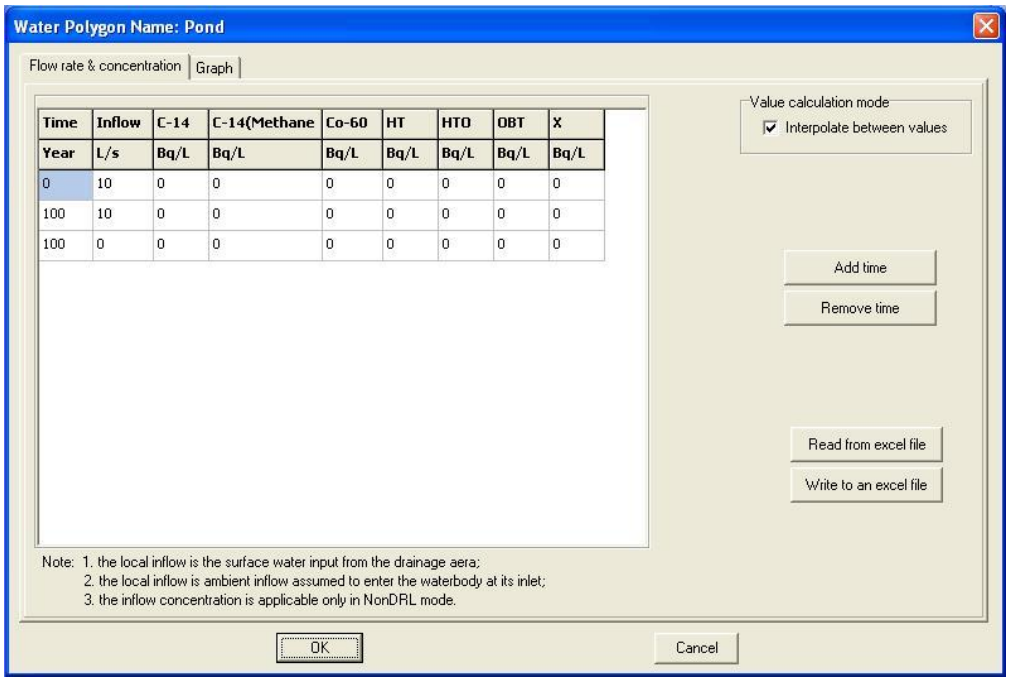
Contents and Features

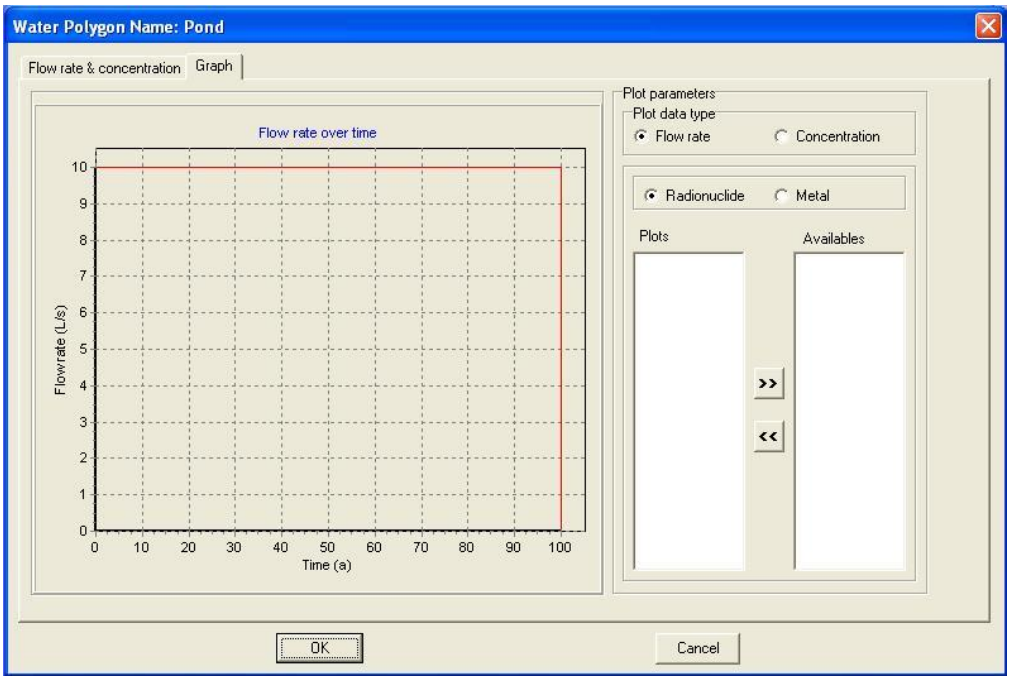
All surface water polygons in an IMPACT scenario have a baseline inflow rate that describes the inflow of clean (uncontaminated) water into that polygon over time. The baseline inflow rate of a water polygon is defined using a data table that is contained in its *Local inflow* data group. This group is listed in the *Attributes* window of each *Surface Water* polygon. The user can edit the attributes of each phase individually.

MULTIPLE INFLOW PHASES ARE NOT PERMITTED IN DRL MODE. CONSTANT VALUE SHOULD BE DEFINED THROUGHOUT THE DURATION OF FLOW.



Baseline inflow data can be accessed by clicking **Local inflow** as show above. The inflow values should be set to be constants in the DRL calculation.





The example shown above is for a water polygon with a baseline inflow that is constant at 10 L/s for a period of 100 years. The use of this dialogue as part of the process of defining water polygons is fully described in Section 4.9.6.

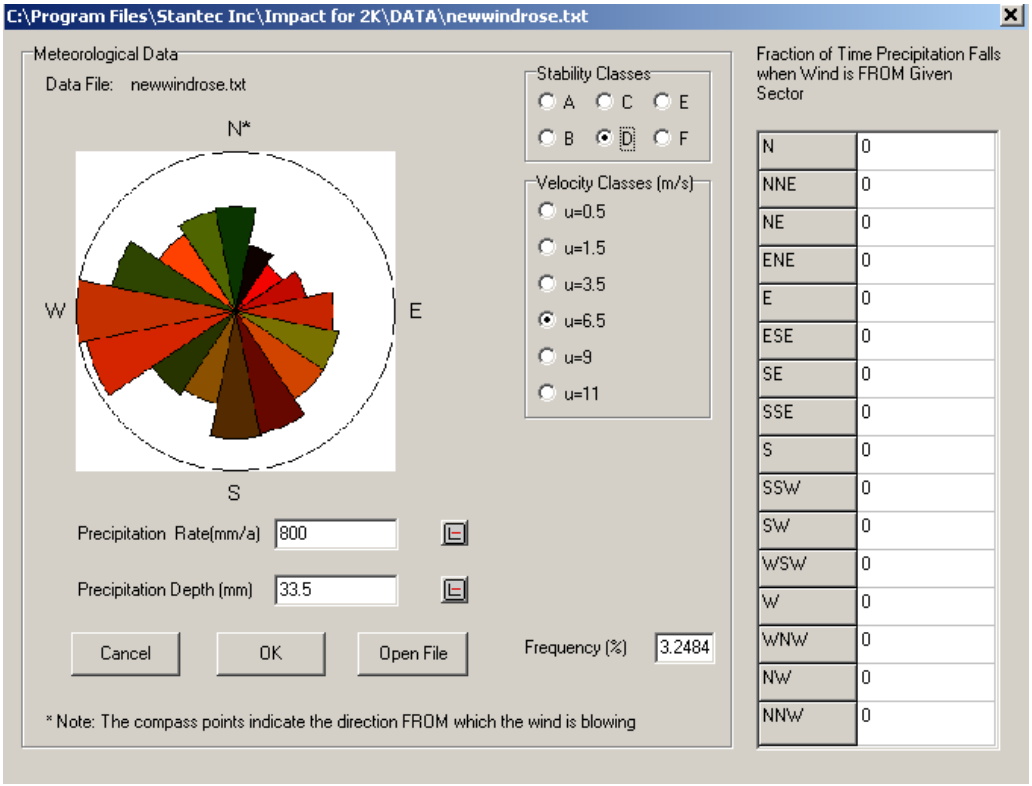
3.6.3 Meteorology Dialogue

Access

This dialogue is opened by choosing **Meteorology**… from the **Biosphere** pull down menu.

Summary of Functions

- define windrose
- define precipitation rates
- define sector specific precipitation frequencies
- import STAR data



Contents and Features

Major meteorological conditions of a scenario are all specified in the *Meteorology* dialogue. This dialogue is depicted in the preceding example. This dialogue contains a graphical representation of the wind rose data that have been specified for the scenario, as well as attributes defining precipitation characteristics (i.e. total annual precip. rate, and sector specific precip. frequencies). All of these meteorological parameters may be modified by the user. A detailed discussion of the use of this dialogue in defining meteorological characteristics of IMPACT scenarios is presented in Section 4.3.3. Note that some inputs appearing to be related to meteorological phenomenon are defined as attributes of certain blocks classes in the Database (e.g. absolute humidity is an attribute of Outdoor Air blocks).

3.6.4 Scale Dialogue

Access

The *Scale* dialogue can be opened by choosing **Scale**… from the **Biosphere** menu. It's also opened automatically whenever a background image is imported into a scenario.

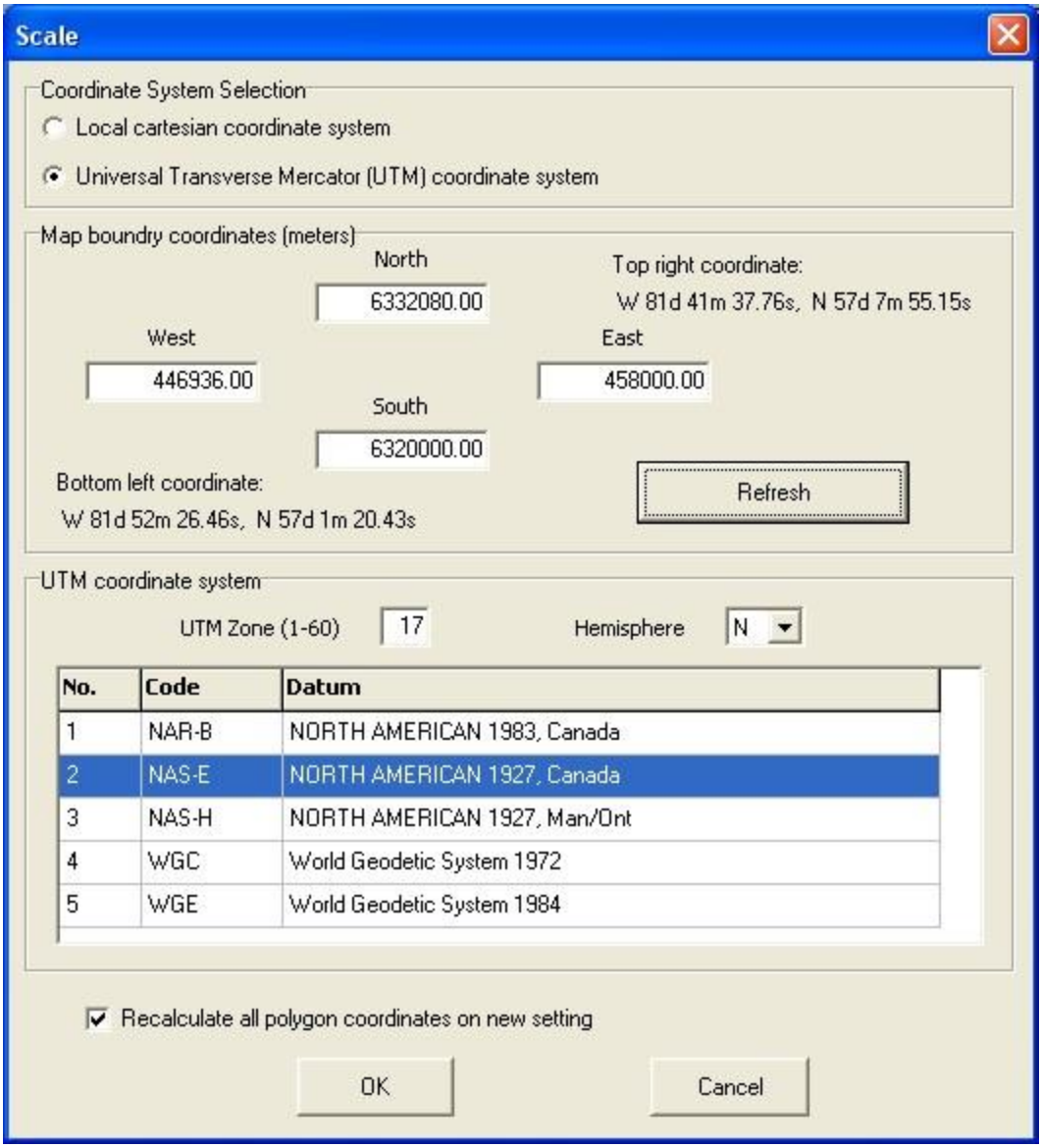
Summary of Functions

- select Cartesian coordinate system or UTM system;
- define map scale and boundaries

Contents and Features

The *Scale* dialogue (depicted below) is used to specify the following:

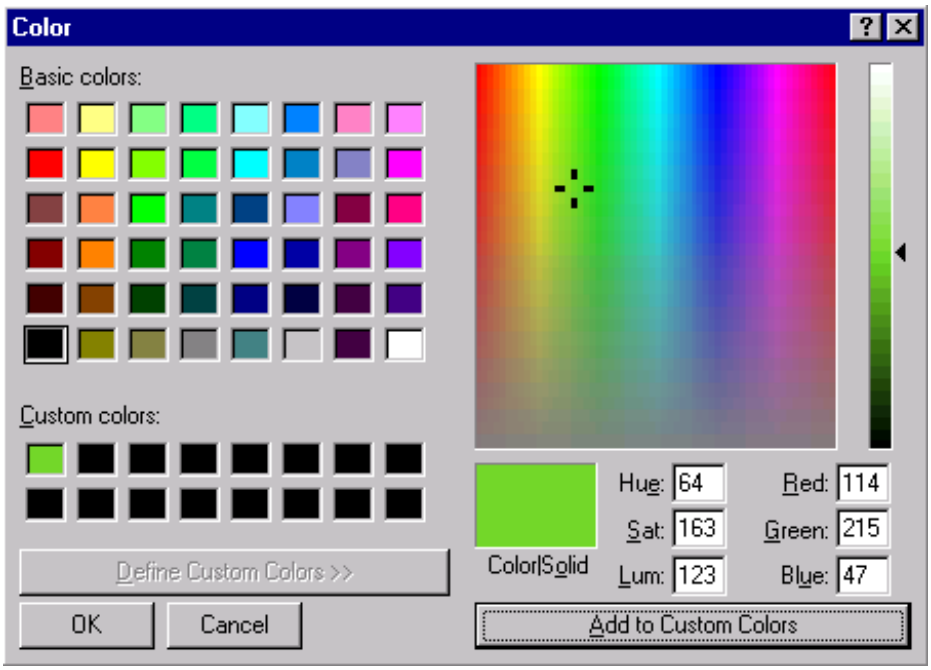
- the coordinate system used in the scenario;
- the boundaries of the modeled area;
- the current map scale when a background image is imported.



A full description of all of the components of the *Scale* dialogue and their use in creating a scenario is presented in Section 4.3.1.

3.6.5 Fill Dialogue

The user can change the fill color of polygons by selecting one or more polygons and choosing **Fill**… from the **Polygon** menu. This opens the *Fill* dialogue where the user can select the fill color either by choosing a standard color from a pop-up menu, or by specifying the red, green and blue components of a custom color.



The changes to the selected polygons' color are not permanent until the user clicks the **OK** button. The use of the *Fill* dialogue in modifying polygon appearance is described in further detail in Section 4.9.5.

3.6.6 Transmogrify Dialogue

Access

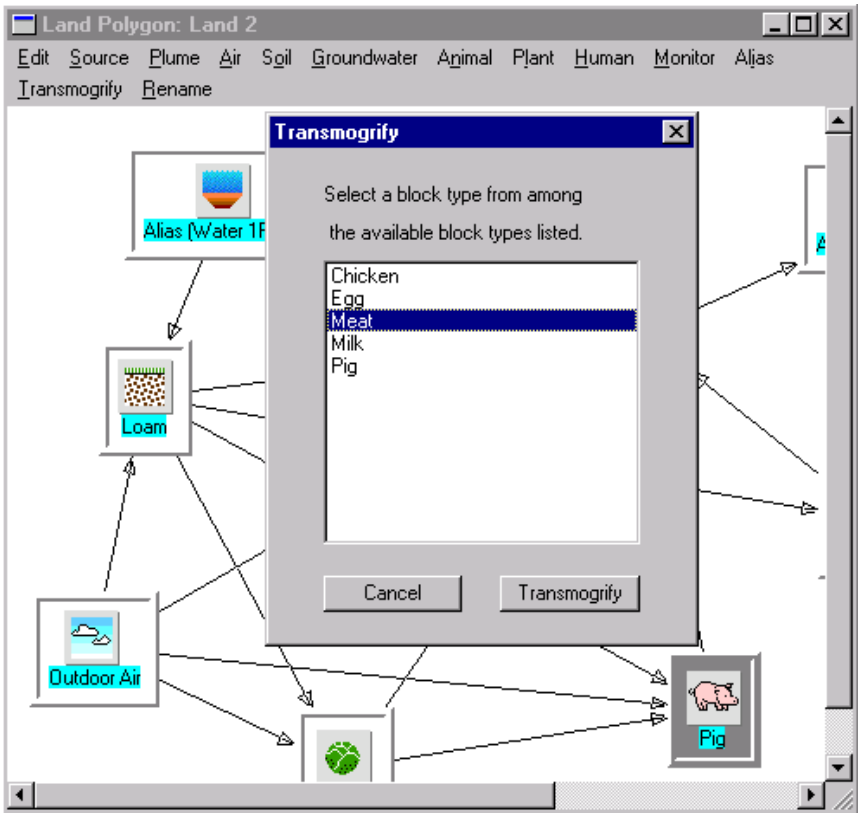
The *Transmogrify* dialogue is opened by selecting a block and then choosing **Transmogrify**... from the Polygon Content window's menu bar.

Summary of Functions

- change block *type (*only within the relevant *Class)*

Contents and Features

The **Transmogrify** command allows the user to change the *type* (but NOT the *class*) of a specified existing block. Only one block may be selected at a time to be Transmogrified. For example, if the user created a *Terrestrial Animal* block of type *Dairy Cow* and later decided to make it a *Beef Cow*, the user could change the block's type using this command.



In the example shown above, an *Animal* block is being transmogrified from its original type of *Pig* to the new type *Meat*. Changing a block's *type* changes the *global* attributes for that block, but not the *local* attributes. If you wish to change the *type* of an *alias*, you must transmogrify the original block at its home location rather than the alias itself. For further description of the Transmogrify process, refer to Section 4.9.7.

3.6.7 Run Dialogue

Access

The *Run* dialogue is accessed by selecting the **Run**... command from the **Simulate** menu or by typing Alt+M, then R.

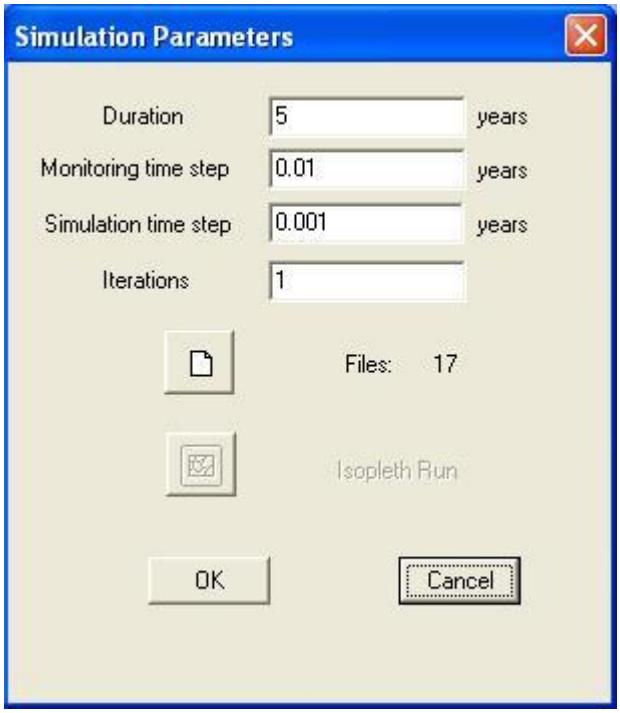
Summary of Functions

- specify simulation attributes
- select output options
- run simulations

Contents and Features

IMPACT simulations are run with the objective of producing specified results from the scenarios that the user has created. All simulations are initiated using the *Run* dialogue (depicted below). The

characteristics of each simulation (e.g. duration, number of iterations, time step) are also specified using this dialogue. The desired output from each simulation is also specified from within the *Run* dialogue.



In the *Run* dialogue, the **Files** button will open the appropriate dialogue to allow the user to specify the monitors to be generated. The number of monitors that have been selected for each output type are shown beside each button. In the example shown above, 17 monitors have been selected to produce output files, but none have been selected to produce graphs. The use of these dialogues is described in full in Section 5.

Clicking the **OK** button will initiate a simulation using the attributes that have been specified in the dialogue. See Section 5.4 for a full description of how to run a simulation.

3.7 Menu Command Summary

In IMPACT, the *Biosphere*, *Polygon* and *References* windows each contain a series of command menus displayed at the top of the active window. The commands in these menus are used to create, modify and save various aspects of an IMPACT scenario, and also to run a simulation and obtain output. The menus summarized in Sections 3.7.1 to 3.7.7 are presented in the order in which the menus appear, from left to right, across the screen in the *Biosphere* window. The commands within each menu are presented in the order in which they appear, from top to bottom, in their respective menus.

3.7.1 File Menu

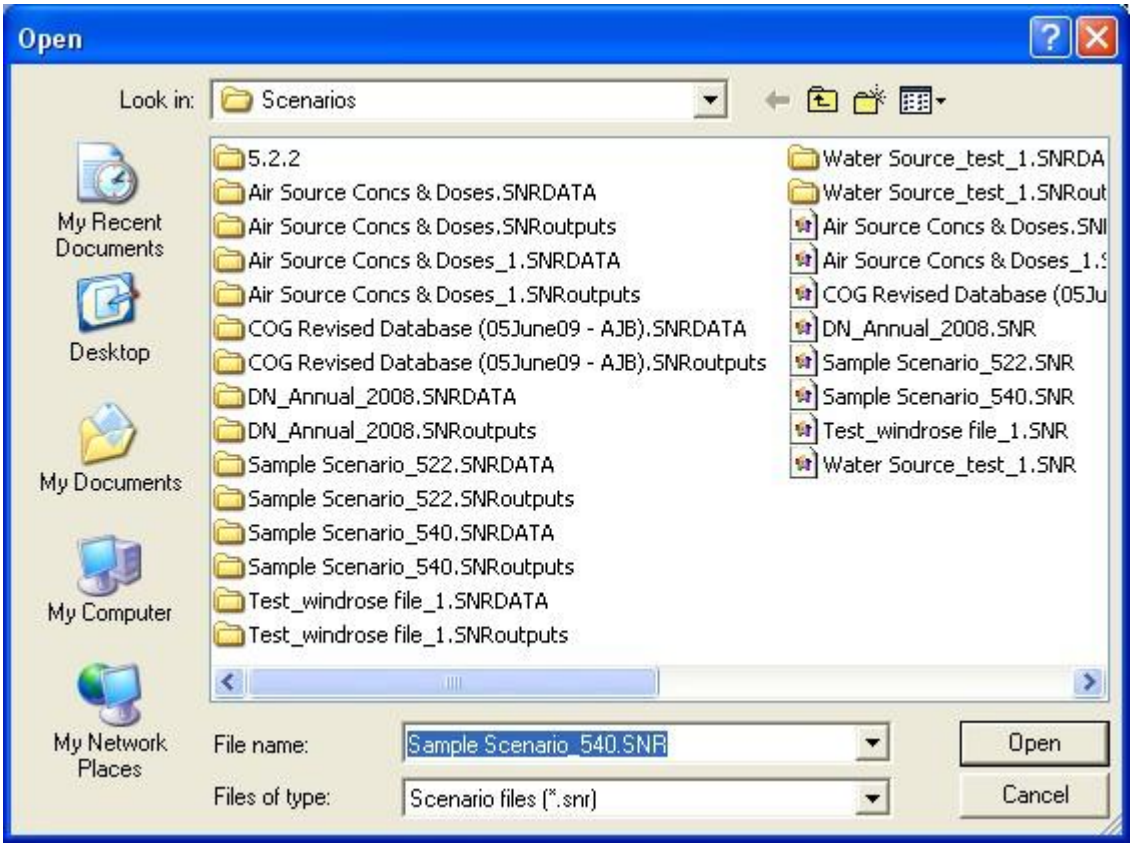
The **File** menu contains commands relevant to operations performed on IMPACT scenario files. This includes the manipulation of scenario files (opening, closing, saving) and the processes of importing, printing and quitting.

New….

This command creates a new, blank scenario, open at the *Biosphere* window, with no polygons present. If a scenario window is already open, and changes have been made since it was last saved, the user will be prompted to save that file, discard the changes or cancel the **New** command.

Open…

Open displays the standard Windows open-file dialogue so the user can choose an existing scenario file to open. If a scenario is already open, and changes have been made since it was last saved, the user will be prompted to save the file, discard the changes or cancel the **Open**… command. This command, and also the **Save**, and **Save As** are mediated through standard windows dialogues (see following example).



Close…

The **Close** command closes the current scenario. If changes have been made to the scenario since it was last saved, the user will be prompted to save the file, discard the changes or cancel the **Close** command.

Save…

The **Save** command saves the current scenario to a file. If the scenario has not been saved before, the user will be presented with the standard save-file dialogue to specify a file name and location.

Save As…

The **Save As**… command allows the user to save the current scenario to a disk file under a different name than that which it is currently saved under. This command is useful if the user wishes to save a copy of a scenario before modifying it further, in case the user wants to go back to the original version at a later date.

Import

The **Import** command allows the user to import graphical images into an IMPACT scenario. Section 4.2 provides detailed information with respect to the process of importing data into IMPACT scenarios.

Export

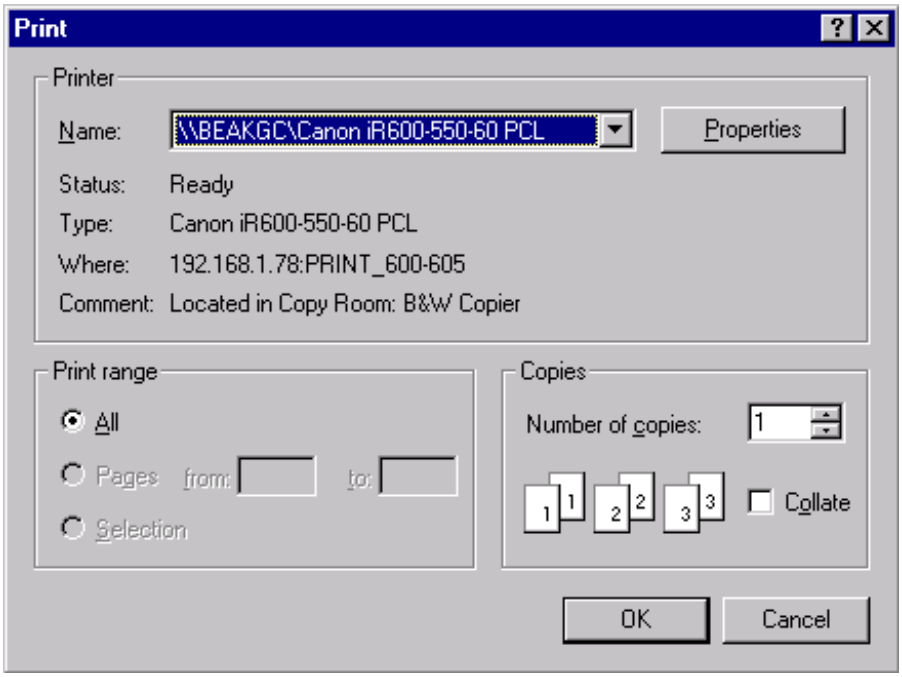
The **Export** command allows the user to export a graphic depiction of the IMPACT scenario (as it appears in the Biosphere Window). Section 4.11 discusses the export options available in IMPACT.

Print Setup…

The **Print Setup** … command allows the user to specify various aspects of any print processes, including print layout and destination. It uses the standard Windows dialogue for set-up.

Print…

The **Print**… command prints the graphical contents of the *Biosphere* window to the currently selected printer. The standard print dialogue for the operating system is displayed to allow the user to select the page range and number of copies to be printed. The figure below shows the print dialogue for IMPACT running on Microsoft Windows NT. Different operating systems may have different print dialogues.



The **Print** command is implemented in the *Biosphere* and the *References* windows. In the references window, the **Print** command is not part of a menu but rather appears as a stand-alone command option in the menu bar. While the **Print** command generates a graphic image in the *Biosphere* window, printing in the *References* window produces text. Refer to Section 4.4 for more discussion on the use of References.

The contents of the various dialogue boxes cannot be printed directly through IMPACT. For these windows, the user could use a screen capture utility program to copy the dialogue's contents to a graphics file, which could then be printed.

Exit…

The **Exit** command quits the IMPACT application. If changes have been made to the scenario since it was last saved, the user will be prompted to save the file, discard the changes or cancel the **Exit** command.

3.7.2 Edit Menu

Commands in the **Edit** menu generally pertain to duplication and deletion of individual polygons or blocks, as well as modification of polygon and block attributes. An **Edit** menu is found in each of the *Biosphere*, *Polygon*, and *References* windows.

Delete…

The **Delete**… command is available in all three **Edit** menus. This command deletes the currently selected polygon(s)/block(s)/text from the scenario. In the Biosphere window, the Delete command can also be used to remove any selected link between polygons (refer to Section 4.10 for discussion of *Linking*). Note that the **Delete** command permanently removes the selected item – a copy is **not** placed in the clipboard. Blocks contained within deleted polygons are themselves also deleted.

Attributes…

While in the Biosphere window, selecting a polygon and choosing the **Attributes**... command will open the polygon's *Attribute* window. This is equivalent to clicking on a polygon with the *Attributes* tool () as discussed in Section 3.6.

3.7.3 View Menu

The View menu is available only in the *Biosphere* window. The commands in this menu control the display of Biosphere contents.

List View

This command switches the display of the *Biosphere* window to *list* mode, opening the List View Window..

Show Names

This command toggles the display of polygon and block names. Changing this setting will redraw the screen.

Show Links

This command toggles the display of polygon and block link percentages. Changing this setting will redraw the screen. If *Show Links* is on, the link arrows will be displayed.

3.7.4 Biosphere Menu

Commands in the **Biosphere** menu control attributes that are relevant to the entire modeled area, which encompasses all polygons in the scenario. The commands primarily allow the user to access major dialogues in IMPACT (as identified in Section 3.6, and discussed in detail throughout Section 4).

Meteorology…

This command opens the *Meteorology* dialogue where the user can specify data which pertain to meteorological or climatic conditions in the area that is being modeled. This dialogue is used to import wind rose data in a STAR data file, and to specify precipitation attributes. The contents of the *Meteorology* dialogue are discussed briefly in Section 3.6.3 and in detail in Section 4.3.3..

Scale…

The **Scale** command opens up the *Scale* dialogue where the user can specify the boundaries of the modeled area and the map scale. Using this dialogue, the user can enlarge or reduce the map scale of a new scenario to any value desired. The scale dialogue is also opened automatically when a graphic image is imported into a scenario. Use of the *Scale* dialogue in defining an IMPACT scenario is fully discussed in Section 4.3.1.

Contaminants

This command opens the *Contaminants* window where all contaminants available for Inclusion in a scenario are defined. Section 3.4.5 describes the general contents of the *Contaminants* window, and its use in creating an IMPACT scenario is reviewed in Section 4.5.

Global reactions

This command activates the *Global Reactions* window. The contents of the *Global reactions* window are described in detail in Section 3.4.6.

Database

This command opens the *Database* window where all global attributes are defined. Note that even though global attributes are displayed in this separate window, they still reside within the current scenario. Section 3.4.8 describes the contents of the *Database* window, and its use in creating an IMPACT scenario is reviewed in Section 4.6.

References

This command opens the *References* window where all references are defined. When this window is active, the user can view and modify existing references, and export or import references to and from text files. The contents of the *References* window are discussed in Section 3.4.9 and details of the use of this feature in creating a scenario are presented in Section 4.4.

3.7.5 Polygon Menu

The Polygon menu contains commands for creating and manipulating polygons. These menu items are enabled only when the *Biosphere* window is active. The process of creating polygons is discussed in greater detail in Section 4.7.

Land

Choosing this command creates a new generic *Land* polygon that represents an area of land with similar characteristics. In the IMPACT model, land polygons are defined as areas of land with similar soil characteristics and relief (as represented by the *slope* parameter). Once created, each *Land* polygon can contain any number of terrestrial blocks that represent compartments found in terrestrial ecosystems. Examples include *Soil*, *Terrestrial Animal*, *Terrestrial Plant*, and *Human*.

Water

This command creates a new generic *Surface Water* polygon, representing an arbitrary body of water of uniform depth. In IMPACT, *Surface Water* polygons are defined as bodies of water with a uniform depth. Typically, a water polygon is used to represent a single water body such as a river, lake or marsh. Large bodies of water can be broken into several surface water polygons if there are distinct areas of unique depth, flow rates or water use. Each water polygon can contain any number of aquatic blocks that represent media found in aquatic ecosystems. Examples include *Pond*, *Sediment* and *Aquatic Plant*.

Fill…

The **Fill**... command opens up the *Fill* dialogue (as described in Section 3.6.5) where the user can specify the fill color of selected polygons. Any changes made in the *Fill* dialogue are applied to all selected polygons. A detailed description of the use of this dialogue is provided in Section 4.9.5.

Open Polygon…

This command opens a polygon's *Contents* window to display the blocks that belong to that polygon. It is equivalent to double-clicking on a polygon.

3.7.6 Scenario Menu

Commands in the **Scenario** menu provide utility functions for monitors and set up a scenario initial condition.

Monitor

Choosing submenu **Reset names** resets all monitor names to auto-calculated default names. The submenu **Delete isolates** removes all isolated monitors (except DRL monitors) in the scenario. No isolated monitor except DRL monitor is allowed to exist in a scenario when it is run. This submenu command helps in cleaning the isolates up.

3.7.7 Simulate Menu

Commands in the **Simulate** menu control options relevant to running a simulation and the generation of output. These topics are fully discussed in Chapter 5 of this manual.

Run…

Choosing this command opens the *Run* dialogue (refer to Section 3.6.7 for a general discussion of this dialogue and its contents). In this dialogue, the user can specify the simulation attributes of duration, time step, plot step, number of iterations, and random seed. Clicking **Run** in this dialogue starts a new simulation with the attributes specified.

Verify

When you select the **Verify** command, IMPACT checks the attributes (global and local) for each polygon and block and verifies that they fall within a valid range. It will notify you if one or more attributes are invalid, allowing you to correct them before running a simulation.

It is recommended that the user does complete a verification procedure after creating a scenario, as this will catch many common mistakes that can lead to errors during calculations. Note that a verification is completed automatically at the beginning of each simulation.

Output Files…

This command brings up the *Files* dialogue where the user can select monitors to create output files, specify whether you want to create backup files, and specify the folder where output files are placed. You can also open this dialogue from within the *Run* dialogue by clicking on the Files button. Chapter 5 describes the processes associated with the *Files* dialogue in detail.

Summary Tables…

This command brings up the dialogue where you can specify the production of *Summary Tables* as an output option. Summary Tables can capture and summarize the output associated with any dose monitors that have already been created in the scenario. This process is discussed in Chapter 5.

3.7.8 Output Menu

Commands in the **Output** menu control give 3 analysis functions: **Graphic analysis, Summary table utility (fixed style)** and **Summary table utility (style options)**. This command menu can only be accessed after a scenario is run.

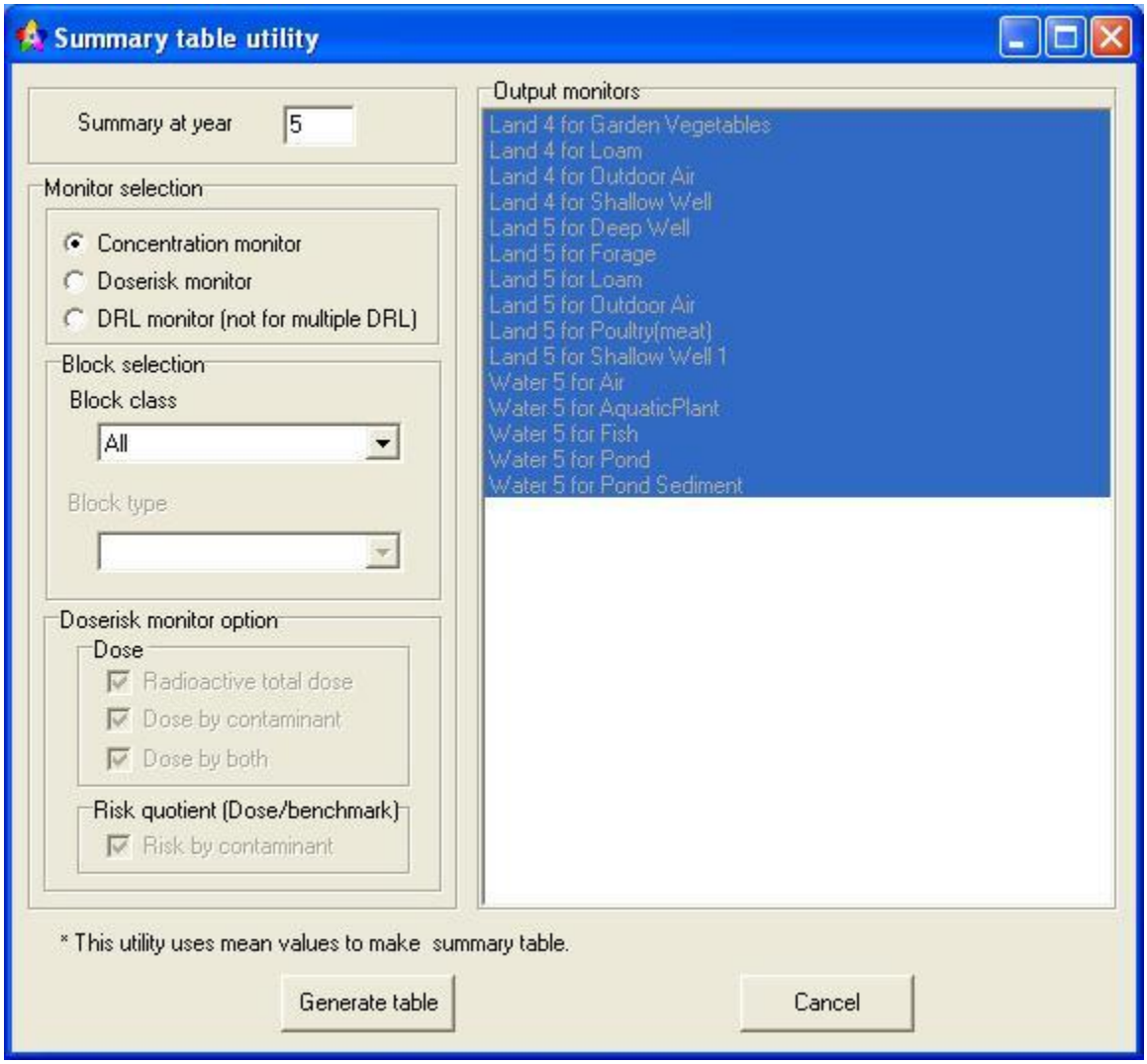
Graphic Analysis

Graphic Analysis opens a monitor selection window and a user can select a monitor to do a graphic analysis based on the latest run results. Any scenario changes made after the run would not take affect until the scenario is run again. Concentration monitor, Dose risk monitor and DRL monitor can be selected and analyzed through the graphic analysis window.

Summary table utility (fixed style)

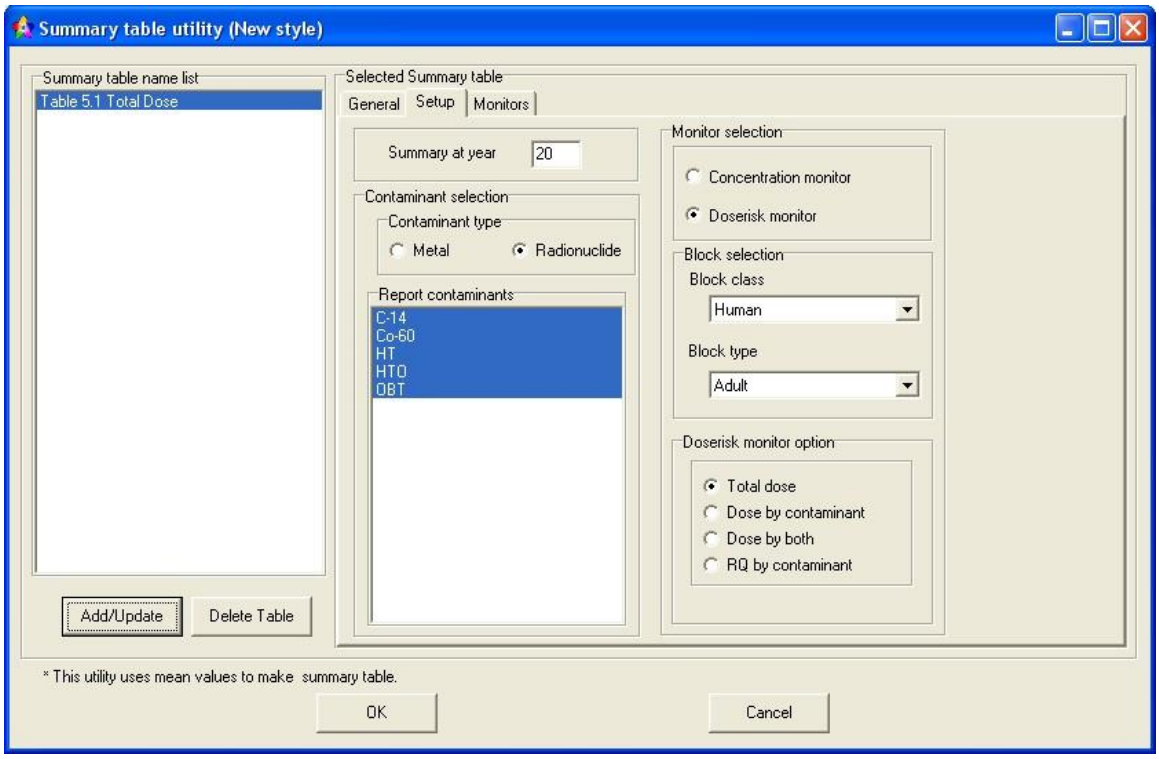
Summary table utility (fixed style) summarizes the latest run results and makes a summary table as the user specifies. The styles are fixed to produce all raw output data cross all monitors on a certain pattern, which may be concentration by contaminants, dose by contaminant or dose by both contaminant and

pathway. These fixed style summary files have the least formatting and they are good for further data processing. The summarized tables are output to excel files as specified by the user. When the product of the contaminant number and the pathway number is bigger than 256, office Excel 2003 and earlier versions can't handle data in this format.



Summary table utility (style options)

Summary table utility (style options) summarizes the latest run results and make a summary table as the user specifies. It is more flexible as to output formats. It is used to produce final report tables. It saves the summary table settings as a part of the scenario and the saved summary tables get updated when the scenario completes its run. An example of a summary table setting is shown below.



3.7.9 Polygon Window Menu Bar

The items available in the menu/command bar In the Polygon Contents Window pertain to blocks that exist only within the polygon that is open. These items include a series of commands contained in the **Edit** pull-down menu as described in Section 3.7.2. There are also a number of pull down menus that allow the user to create various *blocks*, *sources*, and *monitors*. In addition, there are three commands that activate dialogues that then allow the user to manipulate the selected blocks (including *Alias*, *Transmogrify*, and *Rename*, as described in Section 4.9)

Source

The **Source** menu allows the user to establish contaminant sources in either land or water polygons. *Groundwater* and *Dictator* sources are available in the **Source** menu in either land or water polygons. This menu also enables the creation of *Point* Sources in Land Polygons, and *Water Source* sources in water polygons. Selecting any item on the menu creates a *Source* block of the prescribed type. Section 4.8.14 discusses the use of each of the source types in detail.

Various Block Menus

The menu bar in any polygon window contains a series of pull down menus representative of the *Classes* in the database. Each of the *class*-specific menus contains block-create commands for any *type* that has been defined in the menu. The specific set of Block menus that are available depends on the polygon type. While a number of block classes are applicable in both land and water polygons, there are several that are exclusive to either land or water polygons.

The following table summarizes whether a block is terrestrial or aquatic based, or both. Menu items corresponding exclusively to terrestrial blocks are not available in a *Water* polygon, and menus corresponding exclusively to aquatic blocks are not available in a *Land* polygon contents window. Menus corresponding to classes of block types that are appropriate for both terrestrial and aquatic environments are always available.

Block Class	Terrestrial	Aquatic
Air Plume	OK	
Water Plume		OK
Outdoor Air	OK	OK
Indoor Air	OK	
Coastal Water		OK
River		OK
Small Lake (Pond)[1]		OK
Creek		OK
Soil	OK	
Aquatic Animal		OK
Aquatic Plant		OK
Groundwater	OK	OK
Pore Water	OK	OK
Human	OK	
Sediment		OK
Source	OK	OK
Terrestrial Animal	OK	
Terrestrial Plant	OK	

1. This Small Lake block class was called "Pond" in IMPACT Version 4.

The Block menus contain block-create commands for specific block types that have been defined in the database. For example, the *Terrestrial Animal* menu item may have four sub-items titled “Beef”, “Milk”, “Poultry”, and “Eggs”, which correspond to types that are defined for the *Terrestrial Animal* class.

Alias

This command is available in any polygon. Selecting the block(s) to alias and choosing this command creates aliases of the selected blocks. The user can then **cut** these aliases to the clipboard, **paste** them in one or more polygons, and create links between the alias blocks and existing blocks within those polygons. A full discussion of the creation and use of alias blocks is presented in Section 4.8.17.

It is advisable that the user read the *Alias* section in Chapter 4 before first using IMPACT. It is an extremely useful concept that is used frequently while creating a scenario, especially where the contaminants to which a receptor is exposed are located or originate from more than one location.

Transmogrify

This command enables the user to change the type of a block that has already been created. For example, if you created a *Terrestrial Animal* block of type *Beef* and later decided to make it *Poultry*, you could change the block's type using this command. The general aspects of the *Transmogrify* dialogue have been summarized in Section 3.6.6, and the use of this dialogue in the creation of an IMPACT scenario is described in Section 4.9.7.

CREATING A SCENARIO

This chapter presents a detailed description of each step involved in the process of creating a scenario. The main steps are listed below, in the **recommended** order to be performed.

1. creating an IMPACT scenario file;
2. defining the Biosphere;
3. establishing References;
4. creating a database (defining block types);
5. creating polygons;
6. creating blocks;
7. establishing links;
8. running simulations.

Each of these steps is discussed in more detail in this chapter, except for the final step of running simulations that is discussed separately in Section 5. Following these steps in the order in which they are presented is not mandatory, but it will enable the user to create a scenario based on a logical framework and will also help the user to avoid back-tracking in later stages of scenario development. The order suggested above is simply a guideline that can be modified to suit the user's purposes and degree of familiarity with the software.

4.1 Creating an IMPACT Scenario File

When you create a new scenario in IMPACT, you can either start with a new untitled document, or you can use an existing scenario file as a template (refer to Section 3.1 for a discussion of IMPACT file types). The latter approach can save time if you have a common set of contaminants or block types that are used in more than one scenario.

4.2 Importing Data

Some of the information required to create a scenario may be available from other sources in various file formats. To simplify the process of creating a scenario, IMPACT allows the user to import some forms of data in several different graphic and data file formats. Graphic images (e.g. JPEG or BMP files) may be imported as background maps for a scenario, and windrose data in STAR format may be imported to establish wind-related meteorological conditions. The full details of the procedures for each of the available import options are provided in separate sections under the relevant topic headings throughout the remainder of Chapter 4.

A user can also save considerable time in the creation of a database (see Section 4.6) if they have access to any previously constructed Scenario files created previously with IMPACT version 5.2.2. Any or all of the classes in the database can be established simply by copying the relevant ".bin" file from the data folder of

an existing scenario to the data folder for the new scenario of interest. This is done while the scenario file is not open in IMPACT. When the new scenario is opened, the data in the Database will reflect that of the other scenario for whatever classes of ".bin" files have been copied over.

It is recommended that this form of data "import" be conducted prior to creating any polygons or blocks in the new scenario to avoid any inconsistencies within block types. It is also recommended that the "elements.bin" file be copied along with any other ".bin" files copied over, in order to ensure consistency in various contaminant-specific attributes. Note also that the names of the ".bin" folders must remain unchanged in the copy process, or they will not be recognized in the new scenario.

As a recommended practice, a user should keep the broadest and most up-to-date ".bin" files in the Data folder in the IMPACT directory. This way, these data files will be opened at the onset of creation of each new scenario, and the efforts to construct the database should be minimal.

4.3 Defining the Biosphere

Once the user has created a new scenario or opened an existing template, the process of defining the biosphere can begin. This includes specifying the physical dimensions and meteorological properties of the scenario.

4.3.1 Calculating a Map Scale and Boundary

An important step in defining a new scenario is calculating the map scale and boundaries of the area to be modeled. The map scale is used to scale the physical dimensions and spatial separation of polygons when drawing on the screen at different magnifications. The map boundary defines the extent of the area being modeled. The map boundary, in conjunction with the map scale, is used to define the size of the scrollable area available for creating polygons in the *Biosphere* window. The map scale will also serve as the basis of determination of distance between polygons, which is a key factor in the simulation of major contaminant transport processes, including atmospheric dispersion.

A scenario may be created with or without a background Image (typically in the form of some sort of map). It is assumed herein that for any reasonably complex scenario (i.e. with multiple polygons) where geo-spatial attributes are important, a background image will be required. Before creating such a scenario, the user should determine the map scale and boundary by examining existing maps of the site in question. More specifically, the user should determine the actual geographical dimensions (i.e., m east to west and m north to south) represented by the specific map image that will be imported as the background image for the scenario. A background image for any type of map can be used as a starting point for this exercise (e.g. topographic, geologic, soils, and road maps) as long as the map scale and compass direction are provided.

Note that in IMPACT coordinate systems, north is up and east is to the right. Make sure that any images that are imported as a background are aligned and oriented properly.

The scale dialogue is opened automatically after the user imports a background image. The user can also open the dialogue by choosing **Scale**… from the **Biosphere** menu at any time. Once the user has imported

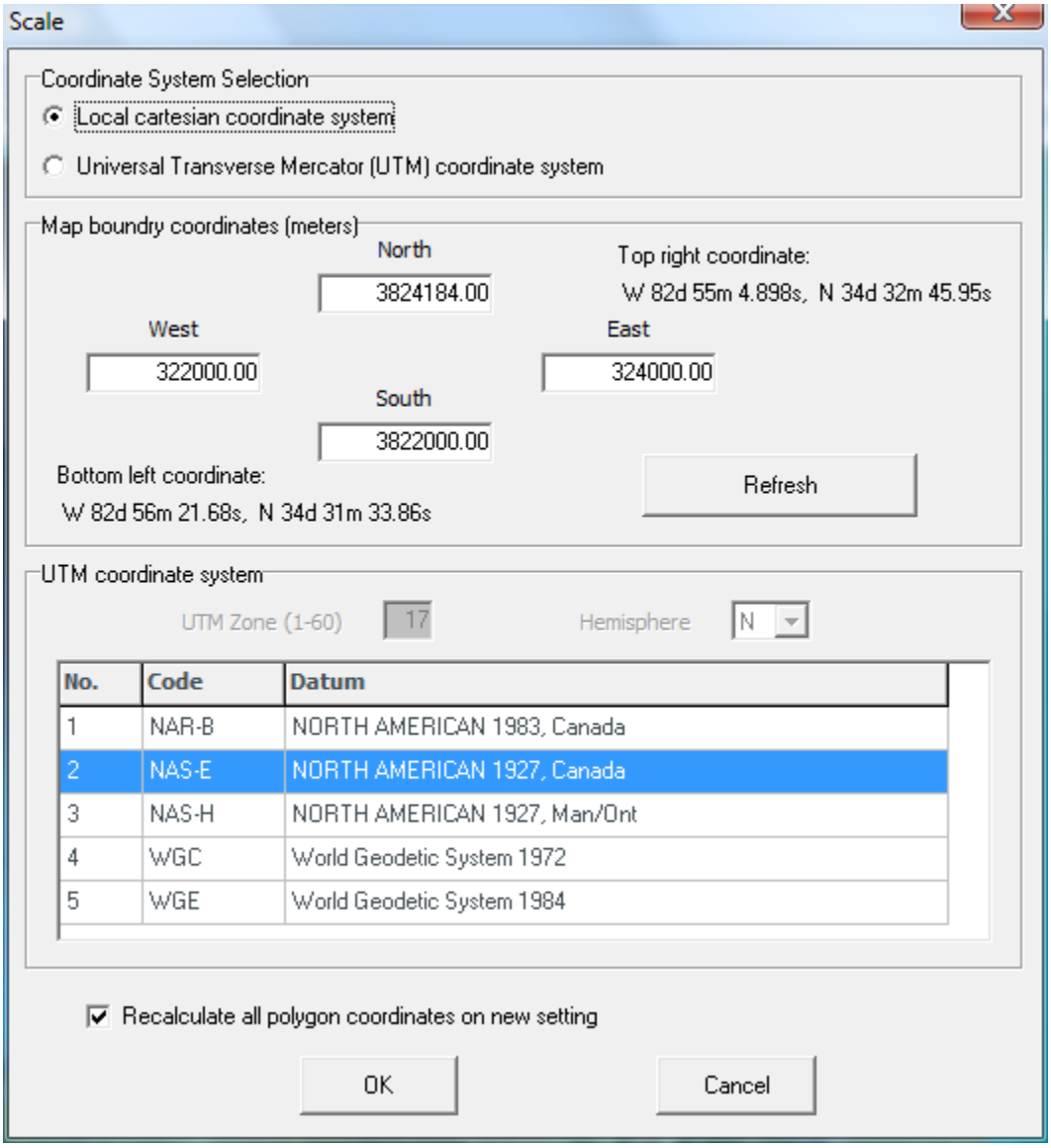
a background image of known dimensions, the real-scale distances from centre to the east, west and south map boundaries are specified as the map boundaries in the *Scale* dialogue (see the following example). The distance to the north is calculated automatically by IMPACT based on the *image* dimensions, and the user should check to see if the value agrees with the known value. The on-screen scale in turn is also calculated by IMPACT, and should also be verified by the user.

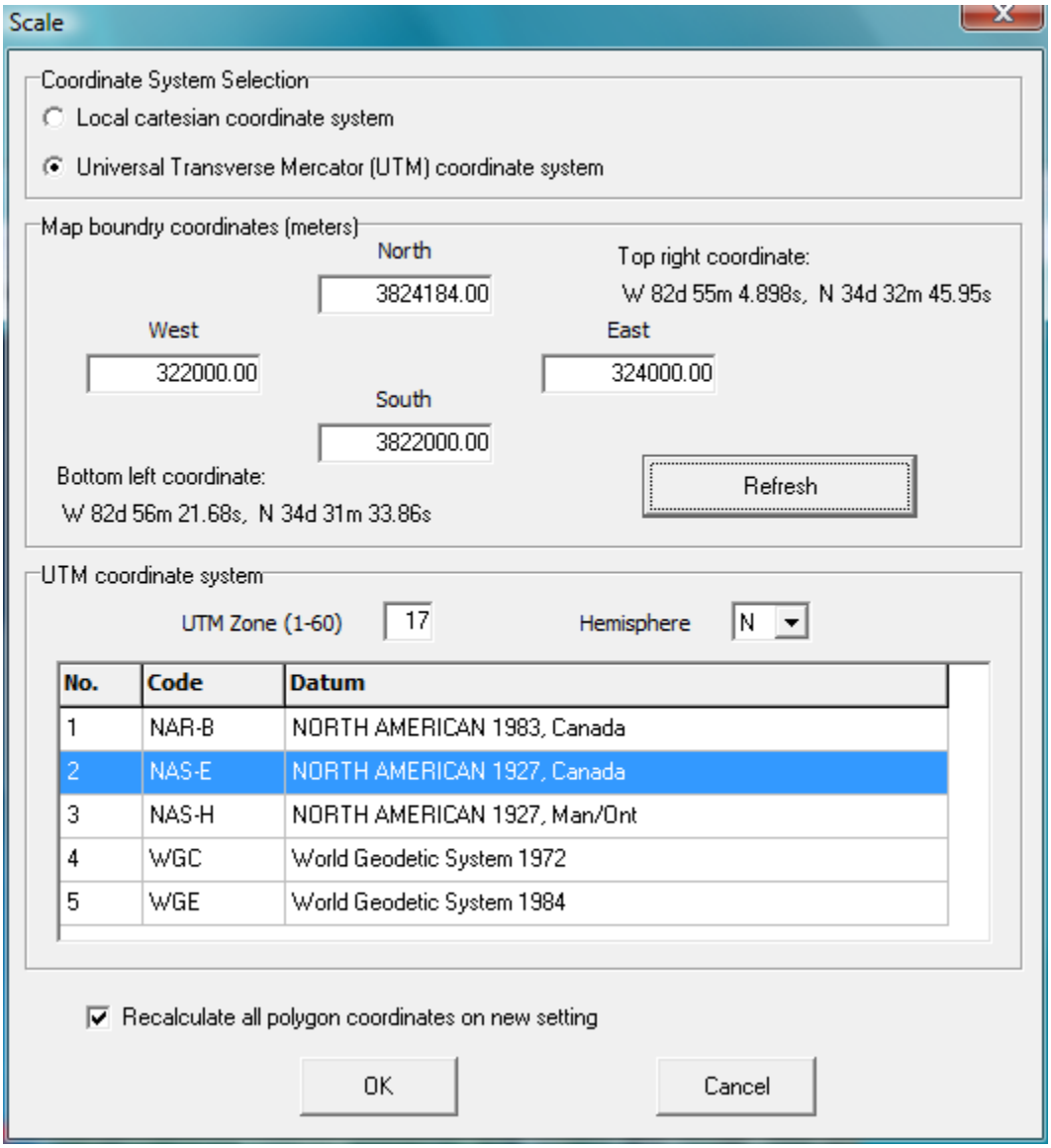
The map boundary defines the size of the area being modeled, and must be large enough to contain all polygons in the scenario. The boundaries are defined by specifying the coordinates of the north, south, east and west limits of the map, using the appropriate map units. The extent of the map boundary and the current map scale together determine the size of the scrollable area available within the *Biosphere* window. For example, the top-left corner of the scrollable area in the *Biosphere* window represents the north-west corner of the map boundary. Similarly, the bottom-right corner of the scrollable area represents the south-east corner of the map boundary.

When the user changes the map scale (e.g. by using Zoom features of IMPACT), polygon areas remain constant, but their size on-screen changes to reflect the new map scale. Whenever the user enlarges or reduces the view of the scenario using the **Zoom** tool or menu commands, the map scale automatically changes (increases or decreases) by a factor of two. This has the effect of reducing or enlarging the usable area in the *Biosphere* window by the same amount.

The scale of the background map is calculated by specifying the coordinates of the top-right point and the bottom-left point on the map. The coordinates can be arbitrary Cartesian coordinates or UTM coordinates (Lat/Long need to be converted to UTM coordinates then input).

When **Local cartesian coordinate system** is selected, only **East**, **West**, **South** and **North** boundary need to be input in meters from the centre point. When **Universal Transverse Mercator (UTM) coordinate system** is selected, besides **East**, **West**, **South** and **North** boundary, **UTM Zone**, **Hemisphere**, and **Map Datum** need to be selected in order to map unique points on the earth.


Scale
Coordinate System Selection
Local cartesian coordinate system
Universal Transverse Mercator (UTM) coordinate system
Map boundry coordinates (meters)
North
3824184.00
Top right coordinate:
W 82d 55m 4.898s, N 34d 32m 45.95s
West
322000.00
East
324000.00
South
3822000.00
Bottom left coordinate:
W 82d 56m 21.68s, N 34d 31m 33.86s
Refresh
UTM coordinate system
UTM Zone (1-60)
17
Hemisphere
N
No. Code Datum
1 NAR-B NORTH AMERICAN 1983, Canada
2 NAS-E NORTH AMERICAN 1927, Canada
3 NAS-H NORTH AMERICAN 1927, Man/Ont
4 WGC World Geodetic System 1972
5 WGE World Geodetic System 1984
Recalculate all polygon coordinates on new setting
OK
Cancel



It is recommended to check the scale consistency between horizontal direction and vertical direction by clicking **Refresh** button after all boundary values are input. After check, a new North value will be changed and displayed in north Input box. This north value is a corrected value that is calculated by applying the horizontal scale in the background Image. A background image scale discrepancy on vertical and horizontal direction is quite possible as the image might be stretched during its creation process. If the difference between the corrected north value and the input value is less than 1%, then the background image is usable and the corrected north value should be used. Otherwise the background image needs to be modified to make the scales on horizontal and vertical directions relatively close and then it can be used. The modification of scales can be done outside IMPACT.

Refresh command also calculates and shows Lat/Long coordinates for the top-right and the bottom-left corner points expressed as UTM coordinates.

The checked box **Recalculate all polygon coordinates on new settings** indicates if the existing polygon coordinates need to be calculated to match the new map settings.

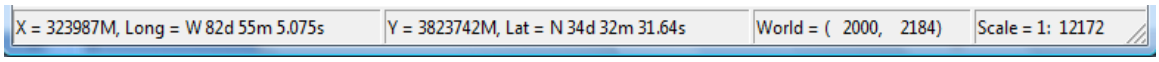
If this is checked, when **OK** is clicked, the existing polygons will stay in the same places on the background image with their polygon coordinates changed to reflect the new map settings. For example, a polygon with centroid coordinates of (1000, 1000) in a map boundary defined by bottom-left point of (0, 0) and top-right point of (2000, 2000) will stay in the same place on the map but the coordinates are re-calculated to be (2000, 2000) when the map settings are changed to a new boundary that has a bottom-left point of (0, 0) and the top-right point of (4000, 4000). This check box needs to be checked when changing coordinate systems, or changing map scales on the same background image.

If this is unchecked, when **OK** is clicked, the existing polygons will move to new places wherever the polygon coordinates determine. In this case, the existing polygon coordinates are separated from the map settings. The existing polygons are shown at the new image locations on the new boundary defined map. Note that the existing polygons might fall off the map if the map settings are too far off from the polygon coordinates as the polygons are out of the defined map boundary, therefore, no polygons will be shown on the map. This check box needs to be unchecked when changing the background image keeping existing polygon UTM coordinates unchanged to match new background image map settings.

Since the computer screen coordinates are in integers (pixels) with some rounding error, it is possible to see that existing polygons are a bit off from the background image. The user needs to move these polygons to be aligned with the background image after changing scales or background images.

It is recommended to confirm map scale whenever it is directly defined or revised. This can be done by comparing the known distance between two points on a map image with the distance that can be calculated based on the coordinates of those same points in the IMPACT scenario.

The user can check the coordinates of any point in the *Biosphere* window by looking at the status panel at the bottom of the window. The status panel displays, from left to right, the coordinates of the point under the cursor, the map boundaries (Width and Height in meters) and the current map scale.



When the user moves the mouse within the *Biosphere* window, the coordinates are continuously updated in the status panel. Changes in the values on both the x and y axes reflect distance along those axes in meters (and Longitude/Latitude for UTM coordinate system).

Note that IMPACT sets up the scale when a background image gets imported. The scale needs to be changed only when switching coordinate system and changing the background image.

4.3.2 Importing Background Images

If the user has external data in a graphic file (e.g. JPEG, BMP) for use as a background image to aid in the digitizing of polygons, the user may import this data into an IMPACT scenario. Most graphics programs have the capacity to produce BMP or JPEG files from other graphical formats. Image files can be imported at any time while building a scenario, but the user is advised to do it prior to creating polygons and blocks.

If the user is importing a file as a background image, make sure to follow appropriate scaling procedures (as described in the previous section). BMP and JPEG files are just graphical images with no inherent scale associated with them, so IMPACT assumes that the real scale dimensions of the Image, as defined by the user in the scale dialogue, are correct. If the user needs to change the map scale to a specific value, the user will have to re-Import the Image and go through the process of assigning scale (as described previously in Section 4.3.1). Once the user has imported the image, the scale dialogue is not accessible.

Bitmap images in BMP or JPEG file format can be imported when the *Biosphere* window is active. To import a graphic file to be used as a background image, simply choose **Import > Graphics Files…** from the **File** menu. When you have selected this command, you will be presented with the standard **file** selection dialogue where the specific file to be imported can be specified.

After an image file has been imported, it will be visible in the *Biosphere* window when in *Graphics* mode (the mode in which all interactions are available).

Only one Graphics file can be used as a background image in an IMPACT scenario. If an image has already been imported, subsequent attempts to import images will simply replace the existing background image with the new image.

4.3.3 Defining Meteorology

The various meteorological attributes specified in IMPACT have relevance to a number of simulated processes (e.g. atmospheric plume dispersion, atmospheric deposition, etc). These attributes are assumed to apply to the entire area encompassed by the map boundaries. In other words, the meteorological parameters defined in IMPACT are Global attributes and are effective throughout the entire Biosphere rather than attributes of specific polygons or blocks.

The meteorological conditions of the modeled area are specified in the *Meteorology* dialogue, which is opened by choosing **Meteorology**… from the **Biosphere** menu. The resulting dialogue (shown in the example below) contains a graphical representation of the wind rose data that are defined for the scenario, as well as attributes defining precipitation characteristics, all of which may be modified by the user. The nature of the various meteorological parameters is described below, and further technical details are provided in Appendix A. An example STAR data file called “newwindrose.txt” is included with IMPACT in the “Data” folder.

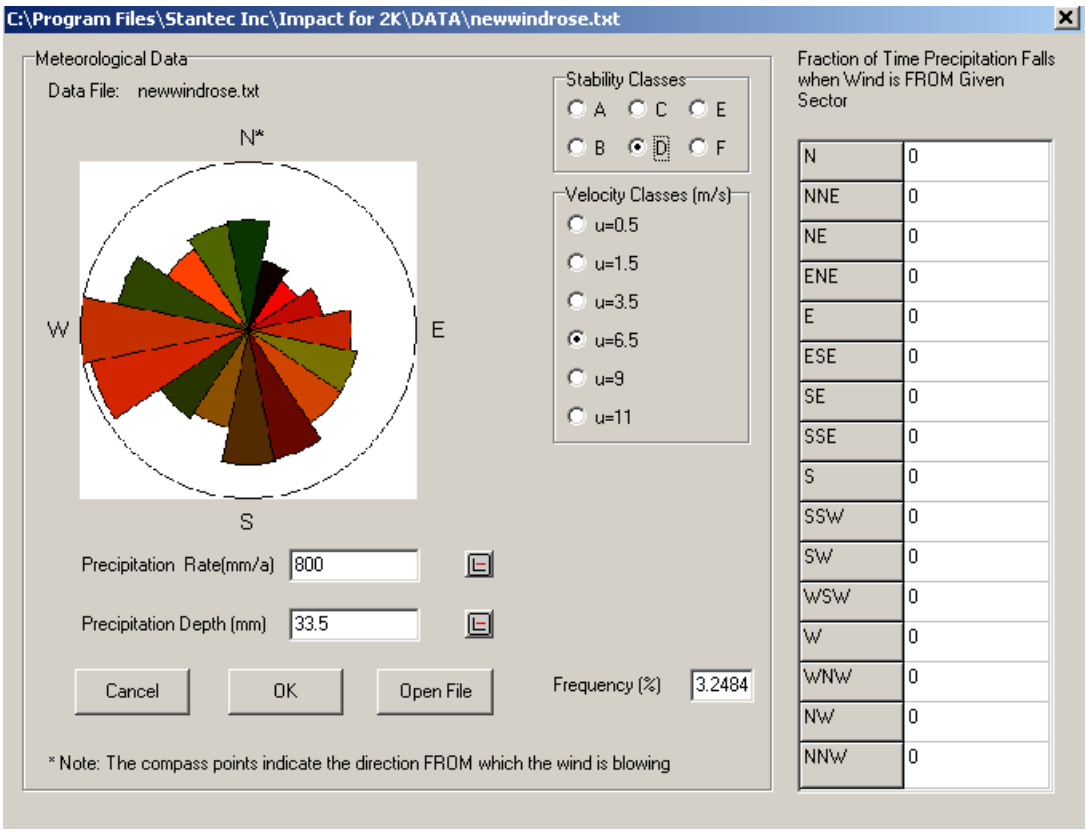
Annual Precipitation [mm/a]

This parameter specifies the average annual precipitation in millimeters per year. In the example presented below, the Annual precipitation has been set to 850 mm. This parameter is used in the calculation of washout of contaminants from the atmosphere to soil, ponds, etc.

Precipitation Depth [mm]

This parameter is not relevant to radiation dose or DRL calculations, and a value is not required for current purposes.

THE DRL SOIL MODEL USES A USER-DEFINED SOIL EROSION RATE, AND THE ATTRIBUTE OF PRECIPITATION DEPTH IS NOT REQUIRED.



Precipitation Fraction

For each of the 16 compass sectors, the precipitation fraction (F_{pj}) specifies the portion of total time during which precipitation occurs within that sector.

Atmospheric Wind Rose

The meteorology/climatology of the modeled area is represented in the IMPACT model as a STAR (STability ARray) tabulation. These data sets are composed of historical triple-joint-frequency data collected over a period of one to five years. Each data set consists of multivariate frequency distributions of surface wind speed versus direction as a function of stability class. A typical STAR tabulation for a single year contains 576 elements (6 stability classes by 16 compass sectors by 6 velocity classes) with each element presented as the percentage of time that the wind is from a particular direction and in a given wind speed class and stability class.

The default STAR data set used by IMPACT for new scenarios (provided In the Data file as "newwindrose.txt") has a uniform distribution by direction, and a stability class distribution as follows:

Pasquill stability category	Frequency %	Mean wind speed [m/s]
A	1	1
B	6	2
C	10	5
D	56	5
E	10	3
F	17	2

The velocity class distributions are weighted such that the mean wind speed for each stability class is equal to the values shown in the table above. This wind rose is typical of average Canadian climatic conditions (CSA, 1987).

STAR data sets are derived from observations taken at first-order or Class A National Weather Service (NWS) stations in Canada and the United States, and are available from Environment Canada or the U.S. National Weather Service. There are other weather stations world-wide which also provide suitable information for STAR data sets.

Open File…

The **Open File**... button allows the user to import a text file containing STAR wind rose data. These data are assumed to apply over the entire area to be modeled. Appendix A describes the required format of STAR data sets in detail. Note that more than one year of STAR data can be imported from a data file. If more than one year of data is imported, IMPACT will randomly select a single year's data to use for each iteration of a probabilistic simulation.

The ASCII text file "newwindrose.txt" included in the "Data" folder can be imported at any time while the *Meteorology* dialogue is open. Importing this file will reset the windrose to its default values.

Velocity class

This control selects the wind speed category for display in the adjacent wind rose. Clicking the up or down arrows in the control changes the displayed velocity class and updates the windrose accordingly. Note that the velocity classes that are considered by the atmospheric plume model in IMPACT are represented by user-defined average wind speeds. The default representative velocities are 0.5, 1.5, 3.5, 6.5, 9 and 11 m/s (as depicted in the example meteorology dialogue provided on the previous page). These are only defaults assumed by the model in absence of user-specification of representative average wind speeds. The user can specify representative values for the 6 wind speed classes in the 3rd line of the windrose ASCII text file. The line should contain 6 values for each 6 classes, arranged from lower to higher, tab-delimited, with no space before values. An example of the windrose file format (with the velocity classes specified to the defaults) is provided in Appendix A. Note that the meteorology dialogue will automatically update to depict the representative wind speeds defined by the user following importation of the new windrose.

Stability class

This control selects the stability class category for wind rose display. Changing the control's setting will display the wind rose frequency for that particular stability class. By selecting combinations of these two settings (velocity and stability), the user can preview wind frequency data for all 36 combinations of velocity and stability classes.

Frequency

This field simply displays, as a point of reference, the frequency of the highest observed frequency for any sector-stability-velocity class combination in the STAR file under consideration. In the graphic display of the windrose, this is the value represented by the outer perimeter of the windrose circle. This value cannot be modified by the user.

In general, all wind-related data displayed in this dialogue are for reference purposes only and cannot be modified directly. If the user wishes to change a frequency value in a windrose data set, the user must edit the text file and then re-import the data in that file.

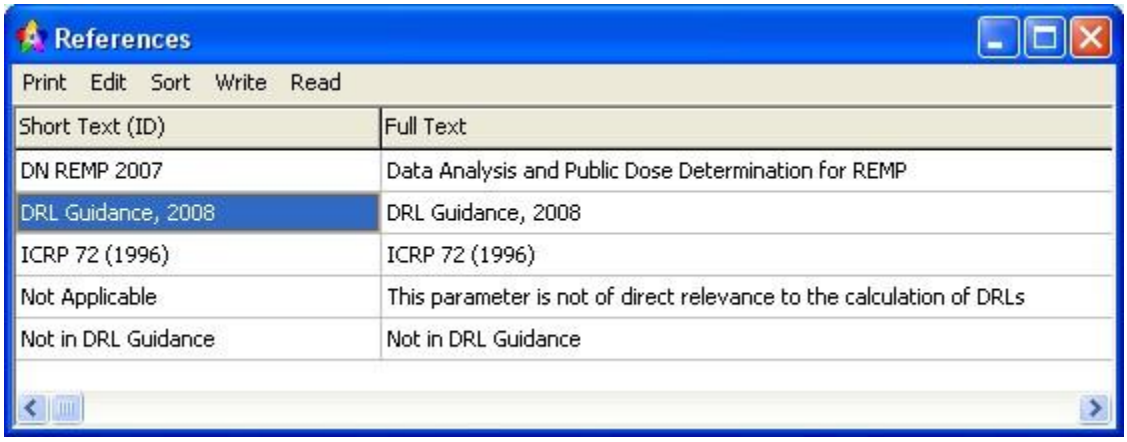
4.3.4 Defining Settling and Washout

In addition to atmospheric dispersion processes (mediated In part by the meteorological data described in the previous section) airborne contaminants are also subject to the processes of gravitational settling and washout by precipitation that can result in the transfer of these contaminants to soil, surface water and plant surfaces. The parameters that are used to describe these processes are *dry deposition velocity* and *wet deposition washout ratio*. These parameters can be specified for each individual contaminant established in a scenario. This is accomplished in the *Contaminants* dialogue (see Section 4.5.2).

4.4 Defining References

Once the Biosphere has been established, the next logical step is to add any relevant references to the scenario before defining any attributes. This way, the references will be available in the **Reference** pop-up menu in attribute dialogues, and can be assigned while editing the attributes of polygons and blocks. Section 4.6.3 provides a detailed discussion of the process of assigning references to attributes.

All references that have been defined in a scenario are displayed in the *References* window (see example below). This window can be opened by choosing **References…** from the Biosphere menu. The long form of a reference is presented only in the *References* window. The long form is typically entered in standard scientific format that provides sufficient information to enable anyone to obtain the full reference document from appropriate sources (e.g. scientific libraries, research institutions). The short form of the reference appears in the **Reference** pop-up menu in various attribute dialogues.



Once you have defined references in this window, you can then assign them to polygon or block attributes by selecting the reference in the attribute's dialogue box (as discussed in Section 4.6.2).

4.4.1 Creating New References

To create a new reference, simply enter appropriate text in each of the fields in an empty row. If there are no empty rows available, simply select **Insert Row** from the **Edit** menu. To remove a reference, simply select the row in the *References* window and choose **Delete Row** from the **Edit** menu.

4.4.2 Modifying References

In the *References* window, simply double-click on any of the two fields for an existing reference to modify the text of that specific reference. Any changes to the references list will require the user to confirm the changes by clicking **OK** in a popup message box saying **Do you wish to save the changes?** in order that those changes are saved.

THE MODIFICATION OF REFERENCE SHORT TEXT IS STRONGLY NOT RECOMMENDED IN IMPACT. THE SHORT TEXT IS USED AS THE INDEX FOR ALL REFERENCE DATA, IF A REFERENCE SHORT TEXT GETS CHANGED, ALL ATTRIBUTES THAT HAVE LINKED TO THIS REFERENCE BY THE SHORT TEXT WILL BE BROKEN, AND THEREFORE NO REFERENCE WILL BE SHOWN FOR THOSE ATTIBUTES.

4.5 Defining Contaminants

In a new scenario, the user creates the list of contaminants that will be present and available for assessment in the scenario. The list of contaminants and some of the attributes that will affect the contaminants' fate and transport are defined in the *Contaminants* Window (see Section 3.4.5 for general description), which is accessed by selecting **Contaminants** in the **Biosphere** menu. Note that you are advised to create contaminants before populating the main Database, since many parameters in that database are contaminant-specific.

4.5.1 Contaminant Name Constraints

The user is generally free to choose any alpha-numeric name for any contaminant being newly created. However, there is a small set of constraints applied to contaminant names that must be followed for correct model function. The constraints relate to a small group of radionuclides that are handled by unique model equations, largely representing specific activity processes. These equations have been coded to recognize precise naming conventions for the parameters for which they are relevant. The following list identifies the parameter naming constraints that are in effect:

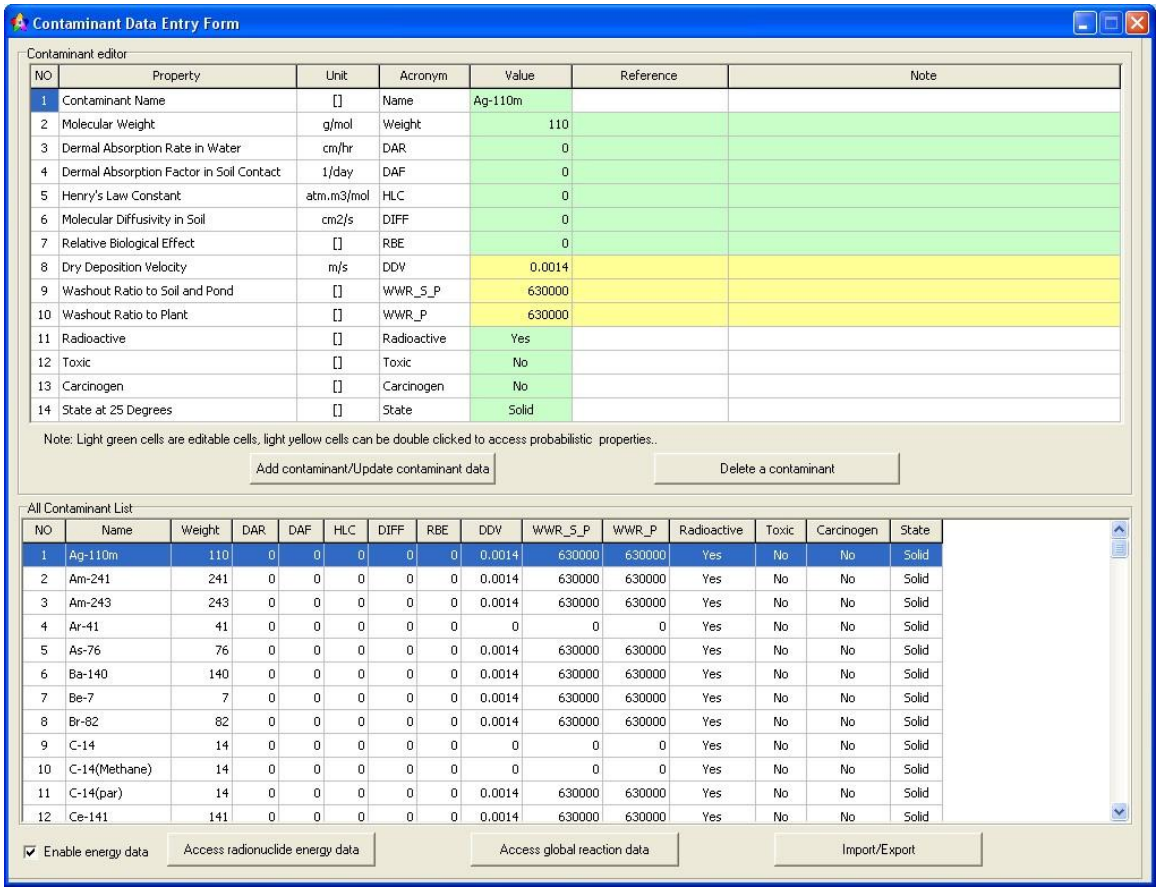
- name of elemental tritium = **HT**
- name of tritium oxide = **HTO**
- name of organically bound tritium = **OBT**
- name of ^{14}Carbon Dioxide = **C-14**
- name of $^{14}CH_4$ (methane) = **C-14(Methane)**

In order to track radioactive decay and ingrowth processes, a subscript "d" is added to the name of a daughter radionulide that is formed by decay reaction during the simulation. A subscript "dd" is added to a grand-daughter radionuclide formed by decay of a "d" radionuclide. This allows the progeny formed by

decay to be distinguished from the same radionuclide that may be released during the simulation. The decay reactions producing "d" and "dd" progeny are specified in the Global Reaction database (Section 4.5.3).

4.5.2 Contaminant Type

It is necessary for the user to define the type of each contaminant in a scenario. In IMPACT contaminants are defined as either radioactive, toxic, or carcinogenic. Only radionuclides are discussed here, given the focus of IMPACT 5.4.0 on DRLs for radionuclides. The contaminant type (i.e. radioactive) is determined simply by selecting the appropriate check-box in the window. In the example provided below, and in all considerations throughout this manual, the contaminant type is *radioactive*.



NO	Property	Unit	Acronym	Value	Reference	Note
1	Contaminant Name	[]	Name	Ag-110m		
2	Molecular Weight	g/mol	Weight	110		
3	Dermal Absorption Rate in Water	cm/hr	DAR	0		
4	Dermal Absorption Factor in Soil Contact	1/day	DAF	0		
5	Henry's Law Constant	atm.m3/mol	HLC	0		
6	Molecular Diffusivity in Soil	cm2/s	DIFF	0		
7	Relative Biological Effect	[]	RBE	0		
8	Dry Deposition Velocity	m/s	DDV	0.0014		
9	Washout Ratio to Soil and Pond	[]	WWR_S_P	630000		
10	Washout Ratio to Plant	[]	WWR_P	630000		
11	Radioactive	[]	Radioactive	Yes		
12	Toxic	[]	Toxic	No		
13	Carcinogen	[]	Carcinogen	No		
14	State at 25 Degrees	[]	State	Solid		

NO	Name	Weight	DAR	DAF	HLC	DIFF	RBE	DDV	WWR_S_P	WWR_P	Radioactive	Toxic	Carcinogen	State
1	Ag-110m	110	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
2	Am-241	241	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
3	Am-243	243	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
4	Ar-41	41	0	0	0	0	0	0	0	0	Yes	No	No	Solid
5	As-76	76	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
6	Ba-140	140	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
7	Be-7	7	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
8	Br-82	82	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
9	C-14	14	0	0	0	0	0	0	0	0	Yes	No	No	Solid
10	C-14(Methane)	14	0	0	0	0	0	0	0	0	Yes	No	No	Solid
11	C-14(par)	14	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid
12	Ce-141	141	0	0	0	0	0	0.0014	630000	630000	Yes	No	No	Solid

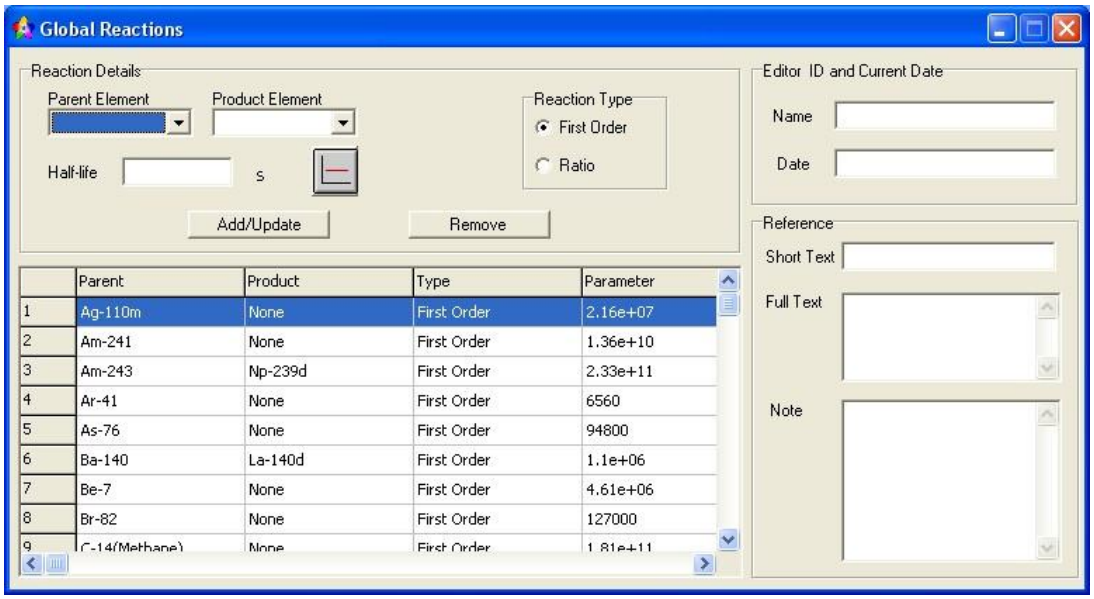
4.5.2 Contaminant Attributes

There is a series of global attributes to be defined for each contaminant. These attributes affect the fate and transport of contaminants in the scenario. There are also attributes of the various block types in the database that are contaminant-specific and also affect contaminant fate, transport and effect for the blocks in question (refer to Section 4.6.3).

A NUMBER OF CONTAMINANT ATTRIBUTES ARE NOT RELEVANT TO DRL MODE

4.5.3 Global Reactions

Some contaminants can be subject to physical, chemical, biological or radioactive decay or conversion processes that give rise to other contaminants. These processes are accommodated in IMPACT by defining global reactions. This is accomplished by selecting the **Global Reactions** command from the menu bar, which opens the Global Reactions dialogue. Here, the parent contaminant, the daughter(s), and the rate of the reaction process are all defined. The rate parameter is usually a first order rate constant (s^{-1}). It may also be a fixed daughter:parent concentration ratio. As with any attributes in IMPACT, all global reactions can be referenced and annotated.



If the user specifies a contaminant to be radioactive, the user should also define a *Global Reaction* that specifies the half-life (in seconds) of the radionuclide. It is NOT an absolute requirement to do this in all cases, but it is recommended, especially for shorter-lived radionuclides where appreciable decay is expected over the simulation period.

In some cases, the rate of conversion or decay of a contaminant will be specific to the media in which the process occurs. In such instances, media specific reactions are defined within the Database window as attributes of the media. For the specific scope of relevance of this manual, media-specific reactions are not considered further.

Radionuclide progeny should be defined as reaction products only if the user wishes to explicitly track the progeny and associated doses. Generally, this will be unnecessary since the daughter dose coefficients implicitly assume progeny in secular equilibrium with the parents, when equilibrium is reasonable given a

typical ingrowth period for each medium (see EcoMetrix/COG, 2008). If the user doesn't wish to explicitly track progeny, the product of the decay reaction should be "None".

IMPACT uses a progeny naming convention to ensure that progeny produced by decay and ingrowth are distinguishable from the same radionuclides released from a facility. First progeny names have a "d" subscript. Second progeny names have a "dd" subscript. A decay chain (A->B->C) is represented as two reactions (A->B_d and B_d->C_{dd}).

Rarely, a radionuclide parent A may decay by isomeric transition. This means that A sometimes decays to a metastable isotope B (which rapidly decays to C), and A sometimes decays directly to C. A branching fraction defines the fraction of transitions that follow each path. IMPACT doesn't accommodate branching factors. Users wishing to explicitly track progeny of Isomeric transitions are advised to assume (conservatively) that all transitions pass through the metastable state.

4.6 Creating a Database

Defining block *types* is one of the most important steps in creating a scenario. Most of the attributes in an IMPACT scenario belong to blocks, and most of these attributes are global (rather than local) and therefore belong to a block ***type*** rather than a specific occurrence of a block. Because of this, it is recommend to specify the global attributes of all block types relevant to the scenario before creating any polygons or blocks.

All block types representing environmental media or receptors are defined within the Database. *Plume*, *Monitor* and *Source* Blocks are the only blocks that are not defined by the user in the Database. Their global characteristics are fixed within IMPACT, and their local attributes are user-defined at the point where they are created in the scenario (refer to Sections 4.8 and4.9.6).

The basic features of the Database window and the means of access have been previously described in Section 3.4.7.

4.6.1 Considerations When Creating a Database

Here are some factors to keep in mind when defining block types.

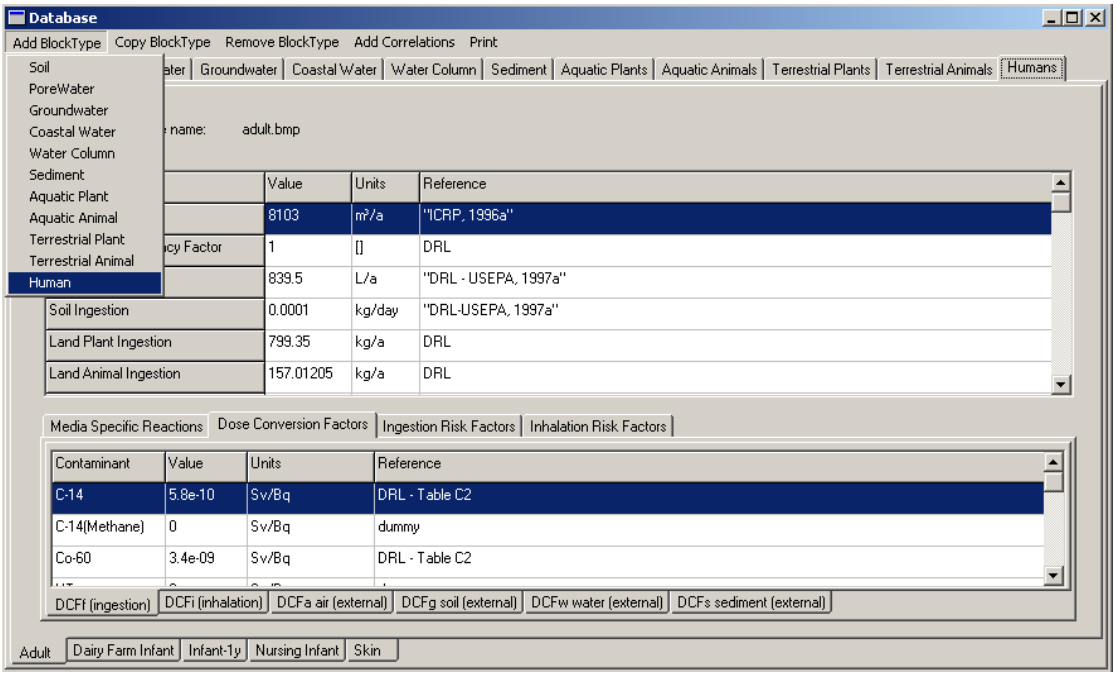
- There are twelve (15) block *classes* defined in the IMPACT database: Outdoor *Air, Indoor Air, Soil, Porewater, Groundwater, Coastal Water, River, Small Lake (Pond), Creek, Sediment, Terrestrial Animal, Aquatic Animal, Terrestrial Plant, Aquatic Plant,* and *Human*. The user cannot define additional classes.
- Dose conversion factors and risk factors are frequently age-specific, as are various other attributes that are not radionuclide -specific. If the user wants to represent receptors of different age classes, the user should define them as separate Block types within a single class (e.g. adult, 5-year old child, infant).

- Dose conversion factors for skin effects differ from whole-body DCFs. If skin effects may be limiting, you should create separate receptor types that are characterized with skin DCFs, rather than whole body DCFs.
- Intake rates and occupancy factors for humans and animals are global attributes which are shared by all blocks of the same type. If you have humans with different lifestyle patterns (e.g. workers who spend 8 hours per day in a polygon versus a resident who spends 24 hours per day in that same polygon) you should represent them as different block types (e.g. “Human (worker)” and “Human (resident)”).
- You may need to define more than one block type for a single animal species if the diet or lifestyle pattern of each type differs significantly. For example, there may be two major breeds of dairy cattle present in an area, which differ in size and various associated physiological attributes (inhalation rate, food ingestion rate, etc.). "Holstein" and "Jersey" blocks could be created, for example.
- Distribution coefficients (K_ds) may be functions of pH, redox potential, and other geochemical parameters of water, sediment and soil. These geochemical parameters typically vary by location. For this reason, you may need to define several block types for each class in order to allow for this variation. An extreme example would be a scenario where each *land polygon* has a unique soil geochemistry and therefore requires a unique set of K_ds to reflect this characteristic.

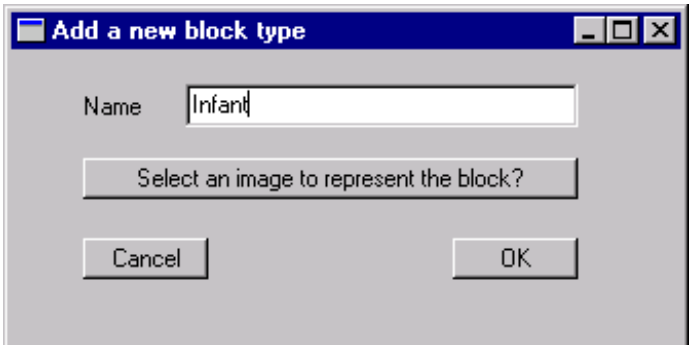
When in doubt, **subdivide!** Create unique block types for each of the possible situations that may need to be represented.

4.6.2 Defining New Block Types

Defining a new block type is a three-step process. First, the user must open the **Add Block Type** menu and select the class to which the user wants to add the new type. In the example shown below, the *Human* class has been selected before defining a new type - “Infant”.

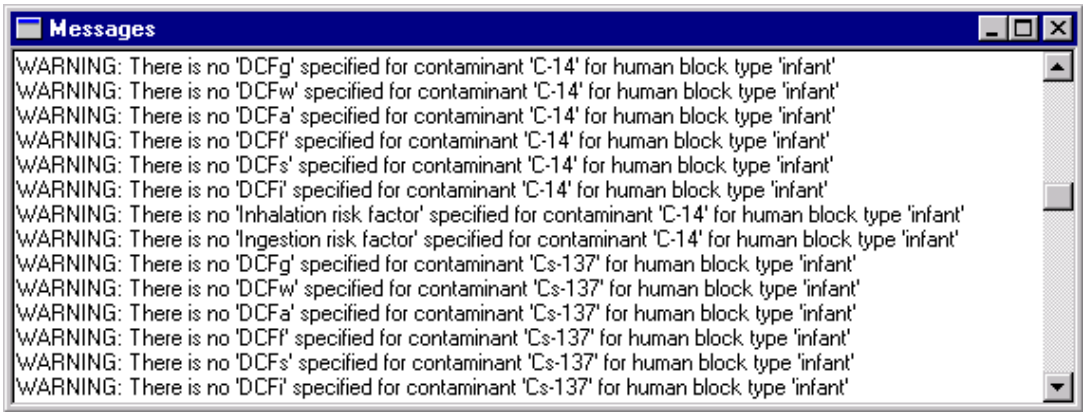


After selecting the class in the **Add Block Type** menu, a dialogue appears where the user can specify the name of the new type and choose the icon for displaying blocks of this type. In continuing with the example above, the dialogue depicted below has been opened for the *Human* class about to be added to the database.



After specifying the name for the new block type (e.g. “Infant”) and selecting a small and large icon (optional), clicking the **OK** button closes the dialogue and adds the new type to the database as a new tab in the *Human* class data group.

All attributes of the new block type will initially be left blank. The user should proceed with specifying these attribute values using the techniques described in the following section. If the user does not specify a value for an attribute, the absence of a value will generate a warning message whenever the verification process is completed (e.g. at the beginning of a simulation).



Another method for creating a new type is simply to copy an existing type with the **Copy Block Type** command while the Database is open. For example, if the user wanted to copy a *Human* "Adult" type, the user would select that block type (by clicking the tab) and choose **Copy Block Type**. The user would be prompted to specify a name and icon for the new type to result from the copy process. Duplicating block *types* using this method copies all attribute values of the selected block type. This is a valuable time saver in instances where many attributes are consistent between the original and the block type being added using the Copy process (e.g. worker adult copied to farmer adult, exhibiting complete overlap in DCFs).

4.6.3 Specifying Global Attributes

In most instances you will be required to specify or modify the global attributes of block types using the techniques described in this section.

Because of the shared nature of global attributes, you must be careful when modifying them. If you change the value of a global attribute, it is changed for every block of the same type within the scenario.

Characteristics of Attributes

A block's global attributes are presented in the database in the form of a hierarchical series of tabs and lists. The name of each attribute is listed to the right of the icon, followed by the attribute's value and units, if appropriate. Attributes may be presented and defined in several forms, as described below.

1) Parameters

Any quantifiable attribute in IMPACT that may have an associated uncertainty is described as a *parameter*. A parameter is any number that can have a probability distribution function (PDF) assigned to it. PDFs are used to quantify uncertainty or variability that may be associated with the parameter. The user can specify one of six different PDFs: *constant*, *uniform*, *normal*, *log-normal*, *triangular* or *set*. A description of these PDF types is provided later in this section. When a simulation is run probabilistically, each iteration can incorporate a new value for the parameter. The value selected in each iteration will be based on the

specified PDF and a random number. All accessible Inputs In the Database are established as parameters, and thus may be assigned a PDF.

2) Constants

Attributes that have a fixed numerical value are defined as *constants*. Unlike parameters, there is no uncertainty associated with the value of constants and therefore they have no PDF. Examples of constants are the X and Y coordinates of polygon centroids, and molecular weights of contaminants. These values remain constant throughout all iterations of a simulation. This is the case for most parameters in the Contaminants list, since contaminant properties reflect molecular configuration and/or physical/chemical properties, which are expected to remain fixed.

3) Ordinals

Attributes that can have only one of a limited number of discrete values (numeric or categorical) are called *ordinals*. When you specify an ordinal, you simply select one value from a fixed set of potential values. Examples of ordinals are contaminant type (Toxic, Carcinogenic or Radioactive) or state (Solid, Liquid, or Gas). There are no PDFs associated with ordinals, and their values remain fixed during a simulation.

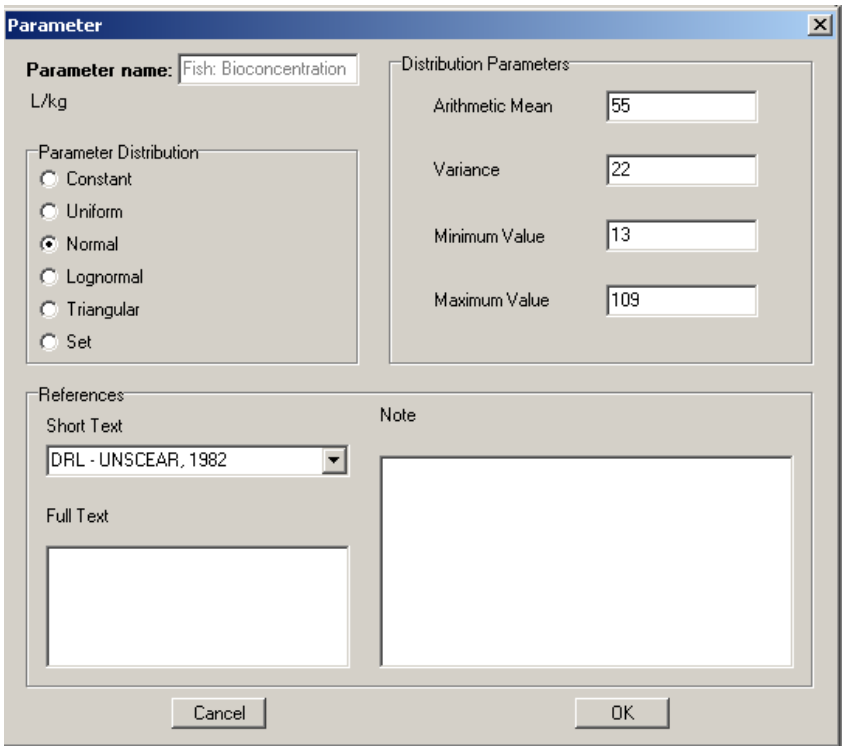
4) Members

Members are, in a sense, indirect attributes by virtue of the fact that they contain a pointer to another distinct attribute. An example of a member is the *parent* of a reaction – the parent (e.g. U^{238}) is an attribute of the reaction (e.g. $U^{238} \Rightarrow U^{234}$) yet it relates directly to another contaminant (U^{238}). Most blocks have a *Database member* as their first attribute. This member points to the global attributes of the block, located in the database.

Assigning Values to Parameters

To define or modify the value of any parameter appearing in the database, simply click on the field. This will bring up a dialogue box where the user can enter values that describe the attribute. Note that any values the user enters need to conform to the units specified in the dialogue box for the attribute in question.

In the *Parameter* dialogue, select one of the six Parameter Distribution types to choose the PDF for the parameter. The default and most widely used PDF is "Constant". Depending on the PDF chosen, the definition of the text fields on the right will change. PDFs are fully described later in this section. In the example provided below, a *Normal* PDF has been chosen, and the maximum and minimum values have been entered along with the mean and the standard deviation.



After selecting the PDF type and specifying a value(s), clicking OK will accept the specified information. Clicking Cancel at any point will leave the parameter unchanged. *References* or *notes* may also be attached to this parameter by selecting a reference from the **Reference** pop-up menu, and by entering a text note in the **Note** field.

Probability Distribution Functions (PDFs)

Each *parameter* is characterized by a Probability Distribution Function (PDF) and up to four numerical values (p1 to p4), depending on the type of PDF chosen. There are a total of six different PDFs that can be used to describe a parameter, and they are summarized in the following table, along with a list of the values that need to be specified.

PDF:	**p1:**	**p2:**	**p3:**	**p4:**
Constant	value	--	--	--
Normal	mean	std. deviation	minimum	maximum
Log-Normal	geometric mean	geometric std. deviation	minimum	maximum
Uniform	minimum	maximum	--	--
Triangular	minimum	mode	maximum	--
	1st value	2nd value	3rd value	4th value, etc.

PDFs are used in probabilistic simulations to define the uncertainty associated with model parameters. At the beginning of each iteration, a different value for each parameter is randomly selected based on the parameter's PDF, and this value is used for that specific iteration. For any parameter with a *Constant* PDF, the value selected for each iteration will not vary. By repeating this process for many iterations, a range of

inputs is specified and therefore a range of results is obtained. The range and distribution of the results provide an estimate of the uncertainty associated with the simulation's output. The meaning of each of the six available PDF types is discussed below.

Constant

The constant distribution describes a value that is constant and does not change from one iteration to the next.

Normal

The three conditions underlying the normal distribution are:

- some value of the uncertain variable that is the most likely to occur (the mean of the distribution)
- the uncertain value is equally likely to be above the mean as below the mean (i.e. the distribution is symmetrical about the mean)
- the uncertain variable is more likely to be in the vicinity of the mean than far away (by definition, 68% of the values in a normal distribution are within 1 standard deviation on either side of the mean).

Log-Normal

The log-normal distribution represents situations where values are positively skewed (most of the values occur near the minimum value). Three conditions for the log-normal distribution are:

- the uncertain variable can increase without limits but can not fall below zero.
- the uncertain variable is positively skewed (i.e. values near the lower limit are more likely to occur)
- plotting the frequency of the natural logarithm of the uncertain variable yields a normal distribution

Uniform

In a uniform distribution, all values between the minimum and maximum are equally likely to occur. The three conditions underlying the uniform distribution are:

- the minimum value is fixed
- the maximum value is fixed
- all values between the minimum and maximum are equally likely to occur

Triangular

The triangular distribution describes a variable where the user knows the minimum, maximum and most likely values. The three conditions underlying a triangular distribution are:

- the minimum value is fixed
- the maximum value is fixed
- the most likely value falls between the minimum and maximum values, forming a triangular-shaped distribution, which shows that values near the minimum and maximum are less likely to occur than those near the most likely value.

Set

The set distribution describes a variable with a fixed number of set possible values. The conditions which apply to set distribution are:

- up to 100 possible values can be specified
- the probability of selecting each value is equal

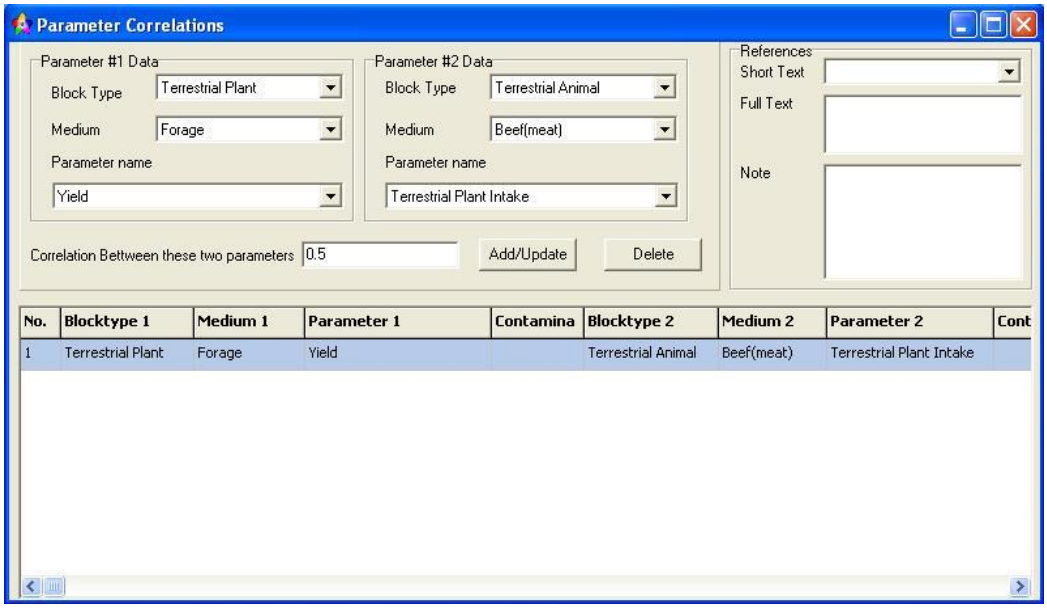
The *Set* PDF is similar to the *Uniform* PDF, except that only discrete values are allowed, rather than a continuous range. You could use this type of PDF for describing parameters where you have obtained different values from several literature sources, each of them equally reliable and equally likely to occur.

Assigning References and Notes

References and associated notes can be shared by more than one attribute. For any parameter, the user selects a reference from the **Reference** pop-up menu, which contains the short form of all of the references that have been defined in the *References* window (refer to Section 4.4 for an overview of creating and modifying references). The long form of the reference is shown in the text field below when the user makes a selection from the pop-up menu.

4.6.4 Correlated Random Numbers.

In completing probabilistic analyses in which several attributes are treated as distributions, there may be instances where it is necessary to consider the inter-relatedness of some attributes in order to ensure that reasonable conditions are simulated (BEAK, 2002). For example, it is very likely that the rates of ingestion of various foods by livestock animals are correlated to their body size. If values for animal size (mass) are selected from the probability distribution function (PDF) in each of a series of probabilistic iterations, then values from a similar point in the respective PDF should be selected for the parameters defining ingestion rates. Otherwise, the animal could be characterized as ingesting unreasonably large amounts of food for a relatively small body size, or *vice versa*. For this reason, IMPACT allows for the correlation of any parameters that are defined distributions. Clicking on the **Correlations** command in the Database window activates the dialogue that enables the establishment of correlated random number functions.



4.7 Creating Polygons

After defining the block types in the database, it's time to create the polygons and blocks that make up the scenario. You can create polygons and blocks in many different ways.

Polygons can only be created within the *Biosphere* window that represents the entire modeled area. There are several methods that can be used to create polygons in the scenario. Each of these methods has traits that make it suitable for use under certain conditions, as described below.

Once the user has created land or water polygons using the following procedures, there are local attributes of both types of polygon that the user needs to specify prior to running any simulations. Sections 4.7.3 and 4.9.6 discuss the procedures for defining polygon attributes.

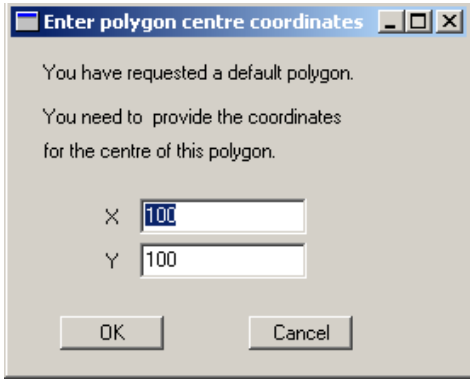
4.7.1 Generic Polygons

Generic polygons can be used in instances where the user is not concerned whether the polygon's shape accurately portrays the area it represents.

There are two ways to create a generic eight-sided polygon.

1) Select either **Land** or **Water** from the **Polygon** menu:

This will place a new generic eight-sided polygon of the specified type at the coordinates specified in the ensuing dialogue (as depicted below).

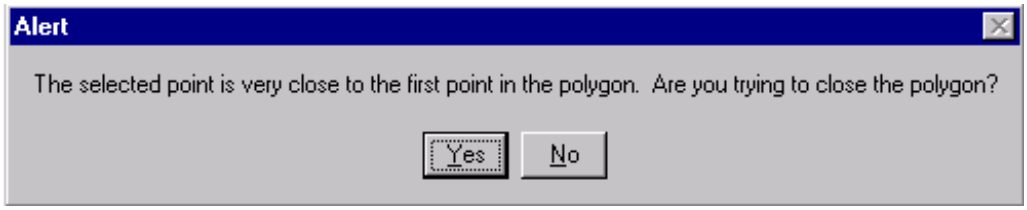


2) Select the Generic Polygon Tool and click anywhere in the *Biosphere* window. This will create an octagonal polygon wherever the user clicks. The type of polygon that is created (*Land* or *Water*) is determined by the polygon *mode*, which is set by either selecting the Land mode button or Water mode button in the main toolbar.

4.7.2 Closed Polygons

This technique allows the user to create polygons whose shape matches the real area that they represent. This method of creating polygons, known as Heads-Up-Digitizing (HUD), is particularly useful if the user is tracing over a scanned image that has been imported as a map (see Section 4.3.2 for a detailed description of the process of importing images).

The user can create a closed polygon by clicking along the polygon's desired boundary with the Closed Polygon tool. The user closes the polygon by clicking with the mouse on or near the first boundary point, and responding to the prompt (as presented below).

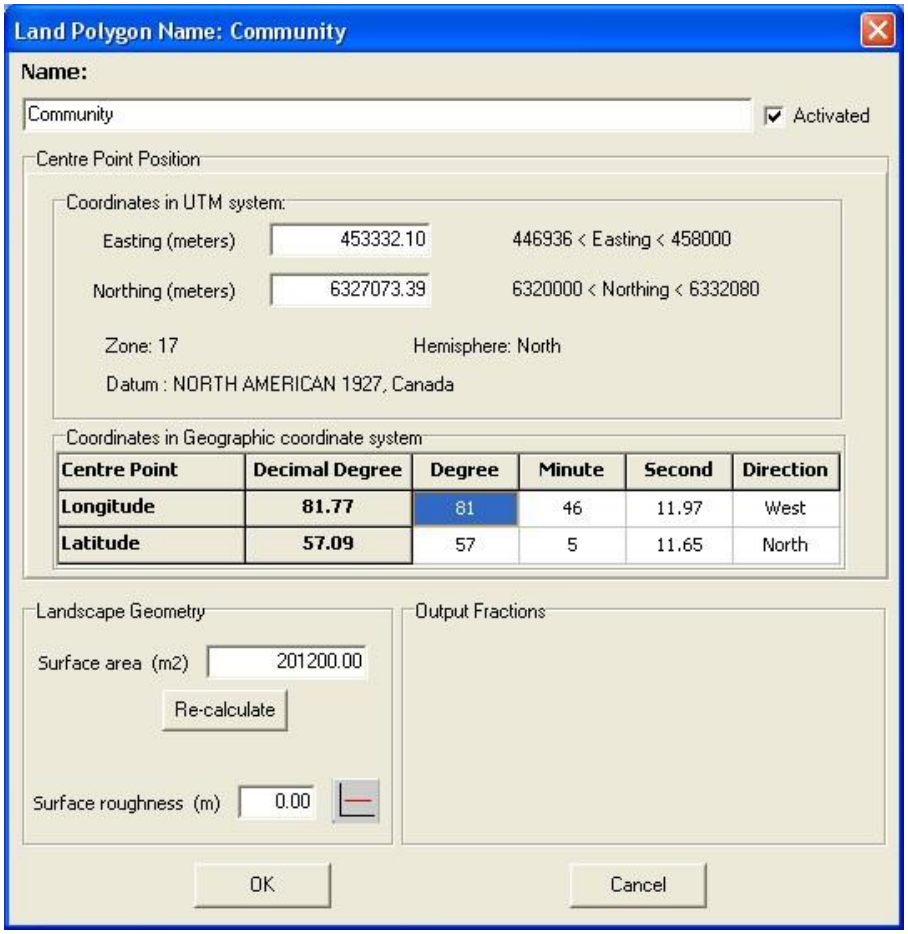


4.7.3 Specifying Polygon Attributes

All polygons that have been created within a scenario have a number of local attributes that the user will need to specify. To access these attributes, select the desired polygon and select **Attributes** from the **Edit** menu or click once on the polygon with the Info tool. This will open the *Attribute* window for the selected polygon.

Land Polygons

Each land polygon created has several local attributes that the user may specify. Each is discussed in context of the following example of the land polygons attribute window.



Coordinates

The first attributes in a *Land* polygon's *Attribute* window are the X and Y coordinates of the centroid of the polygon. These are automatically defined when the polygon is first created and are automatically redefined whenever the polygon is moved (using the Polygon Move Tool – see Section 4.9.3). However, these values can be modified simply by entering new values in the X or Y coordinate data fields in the Attributes dialogue.

Any changes in a polygon's X and Y coordinate attributes will **not** move the polygon within the *Biosphere* window. It **will** change the coordinates of the polygon's centroid, however. The user can display the polygon's centroid by selecting the **Show Links** command in the **View** menu.

Name

It is the polygon ID that distinguishes itself from other polygons. The user can specify the name of the polygon. Note that the Polygon Name is automatically incorporated into the name of blocks and monitors when they are first created within the polygon. If a duplicate polygon name is specified by the user, a error message box will pop up reminding the user to rename the polygon.

The polygon names are also used to form monitor output file names. Since Windows system doesn't allow some special characters (i.e. "/", "\" etc.) in file names, it is strongly recommended to use only alphabetic (include space and underscore etc) and numeric characters to name polygons. If a polygon name consists of invalid characters, then IMPACT will still run, and the results can only be shown in output graphs. No output file will be produced for any monitors in the polygon.

Area

All *Land* and *Surface Water* polygons have an *Area* attribute that is automatically defined when the polygon is first created. The *area* is also automatically redefined whenever the polygon shape is changed using the Edit tool (refer to Section 4.9.5). A manual area re-calculation can be done by clicking the **Re-calculate** button beside the area input box.

The area of a land polygon is used to automatically calculate the distance from the center to the edge of the polygon when it conceptually represents a field. Care should be taken in setting the area if exposure to atmospheric radionuclides originating from soil (via volatilization/re-suspension) is a pathway of concern.

Output Fractions

A *Land* polygon's *Output fractions* specify the relative amount of erosion and runoff originating in the polygon that flows into each "downgradient" polygon to which it is linked. Output fractions are not required or utilized in DRL mode.

THE USE OF POLYGON OUTPUT FRACTIONS IS NOT REQUIRED IN DRL MODE.

Surface Water Polygons

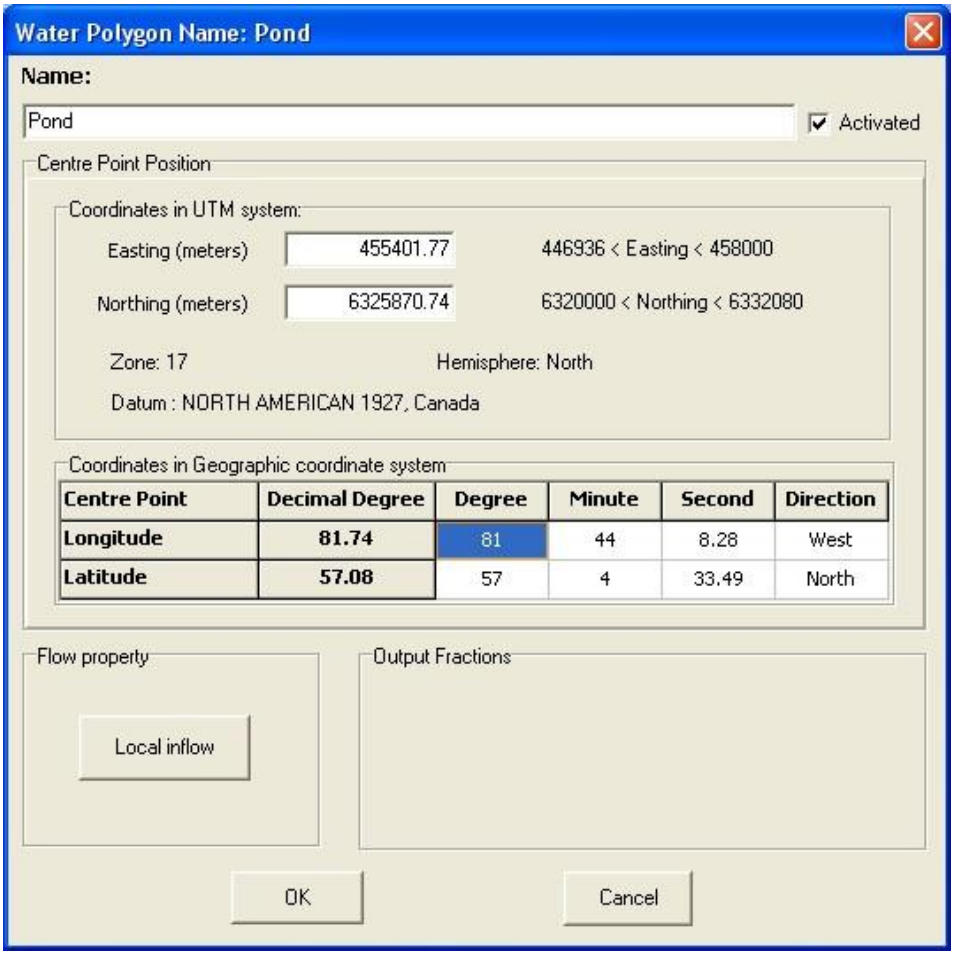
In each *Surface Water* polygon's *Attribute* window (see example below), there are five local attributes that the user can specify.

Name

Surface Water polygons also have a unique user-specified name, as described previously.

Coordinates

As with *Land* polygons, the user may specify the X and Y coordinates of the centroid of the polygon. The same conditions and editing procedures apply to the coordinates of *Water* polygons as to *Land* polygons. The coordinates of a water polygon are determinants of distance from atmospheric sources and are only of direct relevance to model calculations if there is an air-to-water pathway established (i.e. for Pond scenarios). Distances from liquid effluent point sources are specified as attributes of Coastal Water blocks that may be created within a water polygon.



The general attributes position, local inflow, outflow fraction are available to specify through the water window. Some model specific attributes such as area and depth are linked to block class. A user has to create these block instances inside polygons and then access these attributes by double-clicking the blocks.

Output Fractions

A *Water* polygon's *Output fractions* specify the relative amount of water originating in the polygon that flows into each receiving polygon that it is linked to. Output fractions are not required or utilized in DRL mode.

THE USE OF POLYGON OUTPUT FRACTIONS IS NOT REQUIRED IN DRL MODE.

4.8 Creating Blocks

Most blocks cannot be created within an IMPACT scenario until the relevant *block types* have been defined within the database. The procedure of creating block types In the Database is fully documented in Section 4.6 (Creating a Database) and it is recommend that the user review this procedure and define the block types which are expected to be used in the scenario before beginning the process of creating blocks within that scenario.

Considerations When Creating Blocks

Certain blocks are appropriate only in either land or water polygons. The pull-down menus for relevant block types are activated only within the appropriate polygon type (*Land* or *Water*). Some of the limitations are not intuitively obvious but are logical. For example, in IMPACT, a duck is a terrestrial animal and can only be associated with a land polygon. However, there are simple ways to make a duck consume aquatic plants or drink water from a surface water polygon (e.g. using *aliases*). This and other procedures for linking blocks and the conceptual processes that these links represent are fully described in Section 4.10.

Excluding Sources, Plumes and Monitors, there are fifteen (15) classes of blocks in IMPACT that can be created in Land and/or Water polygons.. Any environmental media or receptors required within a scenario must be represented by a block from one of the 15 established classes. As mentioned previously, any block *type* that the user wishes to create in a polygon must have been previously defined within the Database, except for *Plume*, *Source*, and *Monitor* blocks.

Creating Blocks

All blocks are created explicitly while in a Polygon Contents window, which is opened by double-clicking on the polygon, or using the **Open…** command in the **Polygon** pull-down menu. The most common method of creating a block is to select the block's type from the available menus in the Polygon Window. For example, if the user wished to represent agricultural crops within a land polygon, the user would open that polygon and then select the **Terrestrial Plant** menu. That menu would present the user with several sub-items representing the Terrestrial Plant types that have been defined in the Database. Selecting one of these types in the menu will create the appropriate block in the open polygon. If more than one crop was desired, it would be necessary to repeat this process for each crop type, and each would need to have been created in the Database prior to establishing them In the Polygon.

Once any block has been created within a polygon, it can be manipulated or modified in a number of ways. Section 4.9 describes the procedures related to the manipulation and modification of both polygons and blocks.

The user does not have to add any particular type of block to a polygon if that type is not required to effectively represent the exposure pathways of interest

Certain block types can only be created once in any given polygon, as follows:

- Air Plume, Outdoor Air, and Soil blocks in Land Polygons
- Water Plume, Outdoor Air, and Sediment blocks in Water Polygons
- Coastal Water, Small lake (Pond), River or Creek in Water Polygons

The remainder of this section describes each of the block types that the user can create. A list of each block's attributes is included, with global attributes shown in normal text and local attributes shown in *italic* text. If the user is unfamiliar with the distinction between *global* and *local* attributes, refer to Section 3.3.8.

4.8.1 Air Blocks

Each *Land* and *Surface Water* polygon may contain one (and only one) *Air* block that represents the local air in and above the polygon. This local outdoor air block is implicitly linked to *Pointsource* (by means of associated *Plumes*) located in other polygons. A link from the pointsource to an airplume needs to be created explicitly in the polygon that contains the pointsource. Any humans, animals or plants that are linked to the *Air* block can be affected by contaminants that are present in the air, through the processes of inhalation (animals and humans) and deposition (plants). IMPACT allows the creation of *Outdoor Air* and *Indoor Air* blocks. In context of the relevant purposes of this Manual, *Indoor Air* blocks are not considered further.

Contaminants in *Soil* and *Small Lake (Pond)* blocks can be transferred to *Outdoor Air* blocks if a *link* has been made between them. This link represents the processes of dust re-suspension and volatilization of gases that can increase the concentration of contaminants in air.

There are seven global attributes for the Outdoor Air block. Some of these attributes will not be enabled, depending on whether the value assigned to the attribute *Mode* is Indoor or Outdoor.

- Volatilization rate (indoor only)
- Wind speed in mixing zone (Not Applicable to DRL calculation)
- Diffusion height (Not Applicable to DRL calculation)
- Oxidation re-emission absorption factor
- Fraction of year when oxidation occurs

- Stable carbon concentration in air
- Air moisture HTO content : Air HT
- Absolute Humidity (Annual Average)
- Absolute Humidity (Growing Season)
- Absolute Humidity (Snow Free)
- Methane Oxidation Factor

4.8.2 Soil

Each *Land* polygon can contain a *Soil* block, which represents any soil or other geological substrate type that may be present in that polygon. There can only be one *Soil* block in each *Land* polygon, therefore if an area of land has more than one significant soil or rock type, the user may need to subdivide the polygon into two or more smaller polygons. The user does not have to add a *Soil* block to a *Land* polygon if the user does not want or need one.

The attributes that describe *Soil* blocks are:

- Dry bulk density
- Water content
- Erosion rate
- Soil mixing depth
- Re-suspension factor (Non Applicable to DRL calculation)
- Re-suspension layer thickness (Not Applicable to DRL calculation)
- Infiltration rate
- Runoff fraction (Not Applicable to DRL calculation)
- Turnover frequency (Not Applicable to DRL calculation)
- Plant yield
- Cropping frequency
- Plant dry weight:fresh weight ratio
- Distribution coefficient (K_d) (radionuclide-specific)
- Volatilization rate constant (radionuclide-specific)
- Soil-to-plant transfer factor (for determining cropping losses -radionuclide-specific)
- *Irrigation rate*

4.8.3 Porewater Blocks

Porewater blocks are used to represent shallow wells within a scenario. Any Land Polygon can have a single porewater block among its contents. Porewater blocks can be linked directly to soil blocks (as input) and any human or animal that may ingest water from shallow well sources. Porewater blocks can also be linked to terrestrial plants and soil, serving to represent shallow wells as an irrigation source. Transfer from soil to porewater is the only valid input pathway. Links from Air to Soil to Porewater will conceptually represent direct transfer from Air to Porewater as well, eg. HTO transfer from Air to Porewater.

Porewater blocks have only six global attributes (defined in the database) and no *local* attributes, as follow:

- Bulk density
- Porosity
- Stable Carbon in Soil Water (Required for C-14 Specific Activity Approach)
- Soil Water HTO: Air HTO (Required for HTO Specific Activity Approach)
- Distribution coefficient (K_d) (radionuclide-specific)
- Water treatment removal factor (contaminant-specific)

SINCE THE POREWATER IS A PART OF SOIL, IT IS ALWAYS RECOMMENDED TO CREATE A POREWATER BLOCK AND LINK IT TO THE SOIL BLOCK IN A LAND POLYGON.

4.8.4 Groundwater Blocks

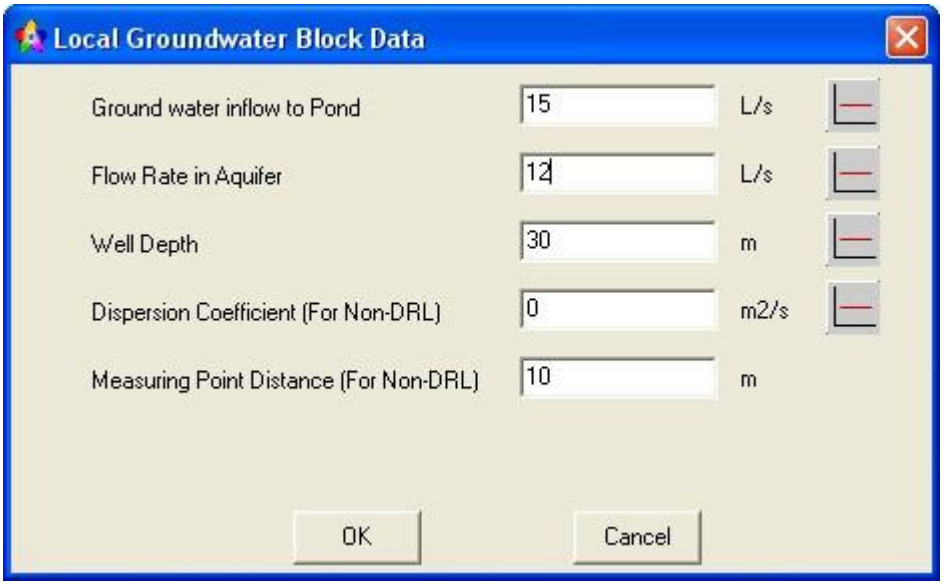
Groundwater blocks can represent any source of groundwater (wells, springs, aquifers) within a scenario, but are primarily intended to represent deep wells (i.e. wells of depth greater than 1 or 2 meters). Any land polygon may contain one groundwater block. Groundwater blocks can be linked as the upstream medium directly to a number of blocks, including sediment, surface water, and any receptor that may ingest water from groundwater sources (including humans). They can also serve to represent a source of irrigation water.

Groundwater blocks have seven global attributes (define din the database) and six *local* attributes (defined in the Groundwater Attribute Dialogue, depicted on the following page), as follow:

- Bulk density
- Porosity
- Stable Carbon In Soil Water
- HTO Ratio Soil Water To Air
- Infiltration to aquifer
- Distribution coefficient (K_d) (contaminant-specific)
- Water treatment removal factor (contaminant-specific)
- *Well depth*

- *Flow rate in aquifer*
- *Surface Water Inflow to pond*
- *Dispersion coefficient* (Not Applicable to DRL calculation)
- *Measuring Point Distance* (Not Applicable to DRL calculation)

A Soil block and a Porewater (shallow well) block must be present within the polygon in order for the Groundwater block to effectively function



4.8.5 Sediment

Sediment blocks represent solid material that has accumulated in an aquatic environment, and are use din IMPACT to represent sediments on a lake or pond bottom, as well as beach sand. Blocks of this class can be added only within *Water* polygons, and receive links from Coastal Water, Small Lake (Pond), or Groundwater Blocks. Sediment can be linked as the upstream medium to animals and humans (enabling both Ingestion and beachshine pathways).

All the attributes associated with *Sediment* blocks are global attributes which are defined in the database.

- Shoreline width factor
- Depth (Not Applicable to DRL calculation)
- Dry bulk density (Not Applicable to DRL calculation)
- Porosity (Not Applicable to DRL calculation)
- Diffusion coefficient (Not Applicable to DRL calculation)

- Interface thickness (Not Applicable to DRL calculation)
- Distribution coefficient (K_d) (radionuclide-specific)

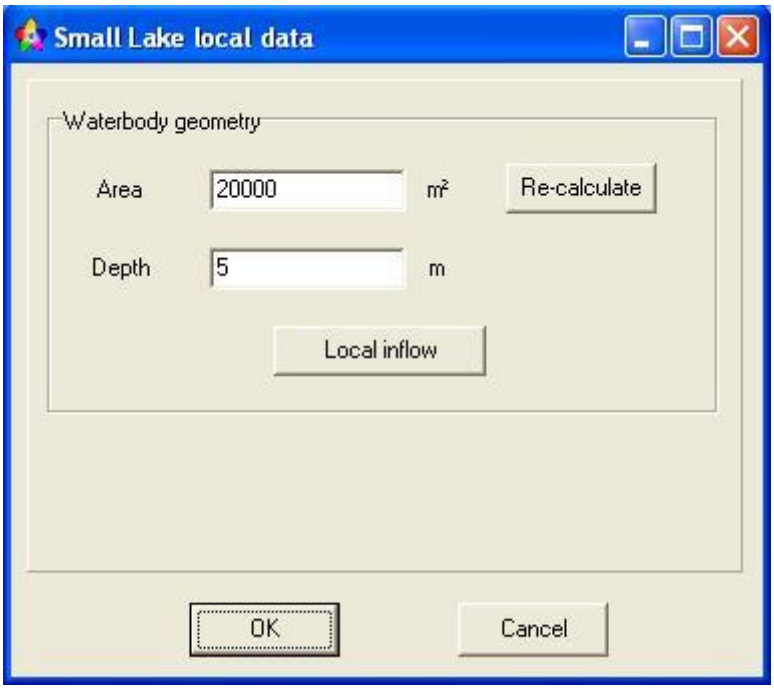
4.8.6 Small Lake ("Pond") Blocks

Each *Surface Water* polygon may contain one *Small Lake* block, which represents the water in the owning *Surface Water* polygon. Small Lake blocks are created within Polygons which have been created to represent entire small lakes or ponds, or lakes in a chain-lakes situation (Non-DRL mode only). The mean depth and surface area of the water body are attributes of the *Small Lake*, therefore a user needs to open the Small Lake block to be able to access these attributes.

There can only be one *Small Lake* block in each *Surface Water* polygon, therefore if the depth varies significantly over its area, the user may need to subdivide the polygon into two or more smaller polygons. The user does not have to add a *Small Lake* block to a *Surface Water* polygon. A Water Polygon could simply contain fish, sediment and aquatic plants. In such a case, contaminant flow would be achieved using Dictator sources (see Section 4.8.13), since the Small Lake (or the Coastal Water block, described in Section 4.8.7) is the primary initial recipient of contaminant transfer in a Water Polygon. The attributes that describe *Small Lake* blocks are:

- Suspended solids
- Sediment deposition rate
- Distribution coefficient (K_d) (radionuclide-specific)
- Water treatment removal factor (radionuclide-specific)
- *Area*
- *Depth*
- *Input fractions*

The input dialogue for a small Lake block allows the specification of the source information and small lake local attributes. The example dialogue below shows a small lake block with area of 20000m^2 and depth of 5m in a water polygon.



4.8.7 Coastal Water Blocks

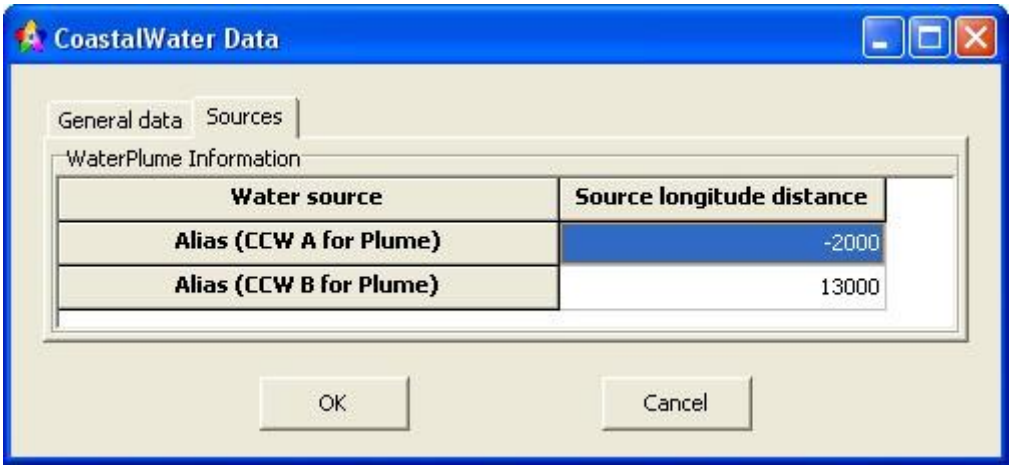
Water polygons created to represent points of potential exposure along the shore of a large lake (e.g. Lake Ontario) or a marine coastline should contain a Coastal Water block, which represents the water in that *Water* polygon. Coastal Water blocks are unique in that they invoke the aquatic dispersion model within IMPACT.

There can only be one Coastal Water block in each *Water* polygon, therefore if the depth varies significantly over its area, the user may need to subdivide the polygon into two or more smaller polygons. *Coastal Water* blocks are not necessarily required in all Water polygons. They must be present, however, if the user wishes to represent aquatic dispersion processes (mediated through the establishment of an aquatic Plume block) in the Scenario.

The attributes that describe *Coastal Water* blocks are identified below. Note that depth and surface area of the water body are attributes of the Water Polygon, not the Coastal Water block.

- Suspended solids
- Deposition Rate
- Sediment dry bulk density
- Distribution coefficient (K_d) (radionuclide-specific)
- Water treatment removal factor (radionuclide-specific)
- *Distance from source (defined In attributes dialogue, as depicted below)*
- *Input fractions*

The input fraction dialogue for a coastal water Block allows the specification of the distance from any points of discharge, which themselves are accommodated in IMPACT using Water Sources linked to Plume Blocks (refer to Section 4.8.14). The example dialogue below shows a Coastal Water block influenced by one plume (i.e. discharge) located 2 km to the left side, and one located 13 km to the right side.



In the Coastal Water Data window, a negative distance for a given water source tells IMPACT to take the "right" velocity, and the fraction of time current is to the "right," from the Local Water Plume Block Data window. A positive distance for a given water source tells IMPACT to take the "left" velocity, and the fraction of time current is to the "left," from the Local Water Plume Block Data window. The magnitude of the distance is the shortest straight-line distance from the source to the receptor, without crossing land.

The coastal water dispersion model uses the average depth of the source water polygon depth and the receptor water polygon depth. The user is advised to create a coastal water block in the source water polygon to define the source water polygon depth.

4.8.8 River Blocks

Water polygons created to represent points of potential exposure along the shore of a river should contain a River block, which represents the river water in that *Water* polygon. River blocks are unique in that they invoke the aquatic dispersion model within IMPACT.

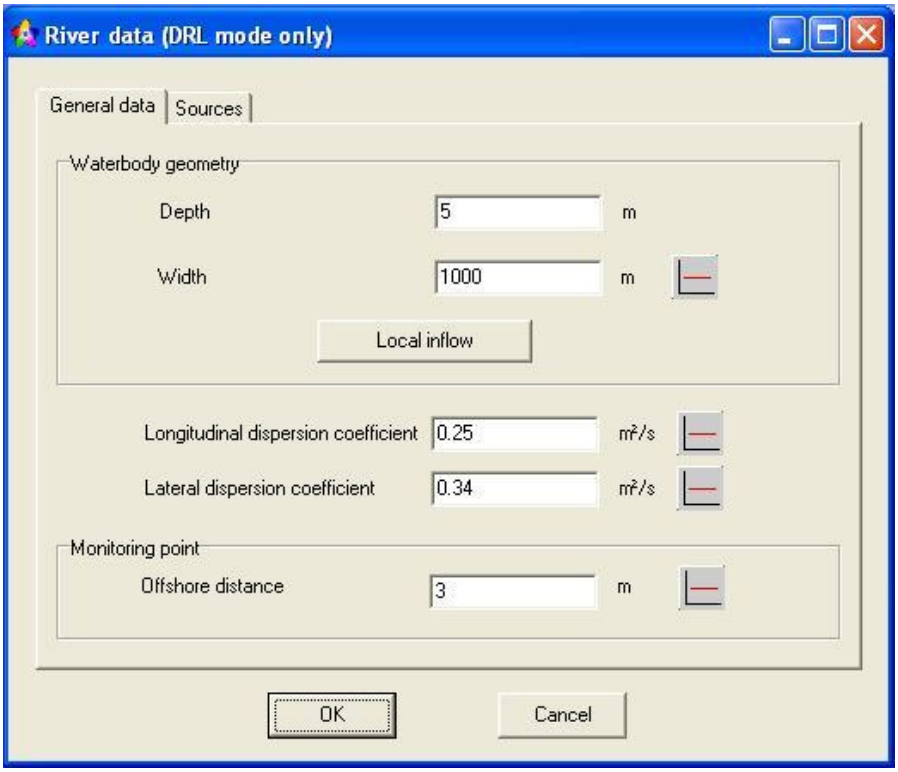
There can only be one River block in each *Water* polygon, therefore if the depth varies significantly over its area, the user may need to subdivide the polygon into two or more smaller polygons. *River* blocks are not necessarily required in all Water polygons. The River block can be linked to water sources directly.

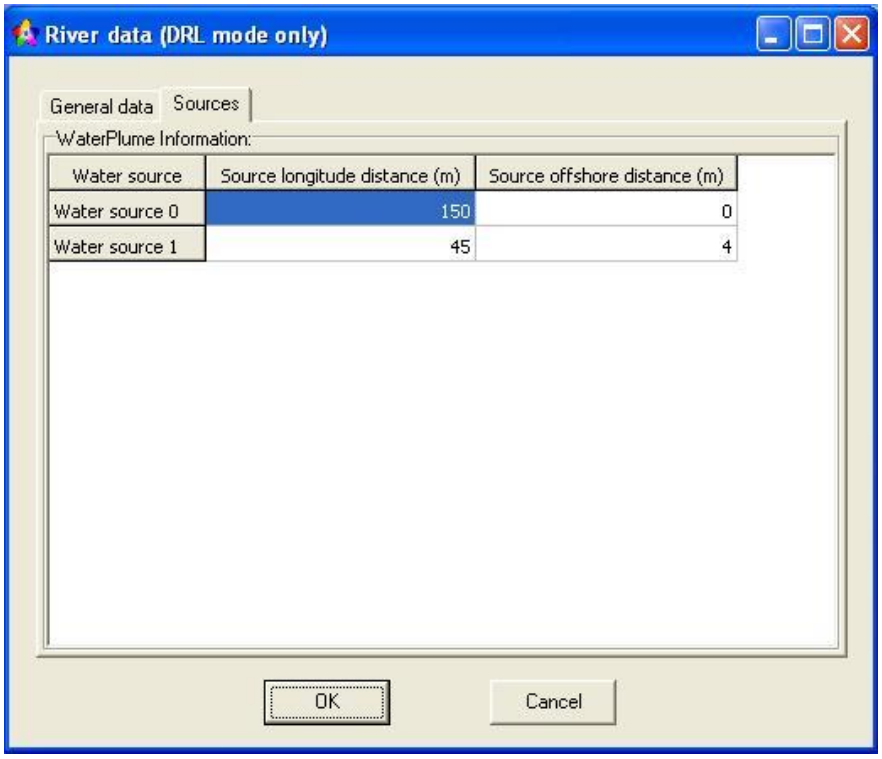
The attributes that describe *River* blocks are identified below.

- Deposition Rate

- Sediment dry bulk density
- Distribution coefficient (K_d) (radionuclide-specific)
- Water treatment removal factor (radionuclide-specific)
- *Depth (defined In attributes dialogue, as depicted below)*
- *Width*
- *Inflow*
- *Longitudinal dispersion coefficient*
- *Lateral dispersion coefficient*
- *Offshore distance*
- *Distance from source*
- *Source longitudinal distance*
- *Source offshore distance*

The input dialogue for a river block allows the specification of the source information and river local attributes. The example dialogue below shows a river block influenced by two water sources (i.e. discharges) located 45m and 150m upstream.


River data (DRL mode only)
General data
Sources
Waterbody geometry
Depth
5
m
Width
1000
m
Local inflow
Longitudinal dispersion coefficient
0.25
m²/s
Lateral dispersion coefficient
0.34
m²/s
Monitoring point
Offshore distance
3
m
OK
Cancel


River data (DRL mode only)
General data
Sources
WaterPlume Information:
Water source
Source longitude distance (m)
Source offshore distance (m)
Water source 0
150
0
Water source 1
45
4
OK
Cancel

4.8.9 Terrestrial Animal Blocks

Within *Land* Polygons, the user can create *Terrestrial Animal* blocks to represent any animal that may reside within those polygons. This is done simply by selecting a desired type of animal from the **Animal** pull down menu. As with any class in the database, the only *types* of *Terrestrial Animal* blocks that the user may create within the scenario are those that have already been defined within the database (refer to Section 4.6).

Terrestrial animals may receive links from Air, Soil, Porewater, Groundwater, Plants, Coastal Water, River, and Small Lake Blocks. They may be linked as upstream media to other animals and humans.

All but one of the attributes associated with *Terrestrial Animal* blocks are global attributes, which are defined in the Database. The only local attribute is an *Input fraction(s)*. The member attributes contained in the *Input fractions* data group are used to specify the percentage of each exposure medium (eg. air, soil, water, plant food and animal food) which each input link contributes to the animal.

The global attributes of *Terrestrial Animal* blocks are:

- Air intake
- Soil intake
- Water intake
- Plant intake
- Animal intake
- Aquatic plant intake
- Aquatic animal intake
- Body mass (Not Applicable to DRL calculation)
- Water occupancy factor (Not Applicable to DRL calculation)
- Water Intake Fraction Obtained from Drinking
- Water Intake Fraction Obtained from Plant Feed
- Water Intake Fraction Obtained from Decomposition
- Water Equivalent of Dry Matter
- Isotopic Discrimination Factor
- Animal Dry/Fresh Weight Ratio
- Water per Total fresh Weight Food
- Ingestion transfer factor (radionculide-specific)
- Inhalation transfer factor(radionculide-specific)
- Risk factor (internal) (radionculide-specific, Not Applicable to DRL calculation)
- DCF_a (air external) (radionculide-specific, Not Applicable to DRL calculation)

- DCF_g (soil external) (radionculide-specific, Not Applicable to DRL calculation)
- DCF_w (water external) (radionculide-specific, Not Applicable to DRL calculation)
- DCF_s (sediment external) (radionculide-specific, Not Applicable to DRL calculation)
- DCF_f (internal) (radionculide-specific, Not Applicable to DRL calculation)

4.8.10 Terrestrial Plant Blocks

Within *Land* polygons, the user can create *Terrestrial Plant* blocks to represent any plant that may grow within those polygons. Multiple plant blocks are permitted. As with any block, the only available *types* of *Terrestrial Plant* blocks are those that have already been defined within the database (refer to Section 4.6). Plants can receive links from Air, Soil, Porewater, Groundwater blocks, River blocks, as well as Small Lake (Pond) and Coastal Water blocks (both as aliases). All but one of the *Terrestrial Plant* attributes are *global* attributes (defined in the database).

- Yield
- Removal half-life
- Effective deposition duration
- Irrigation fraction
- Foliar interception fraction
- Water retained per leaf area
- Harvest Index
- Hold-up time
- Irrigation frequency
- Leaf area index
- Plant dry/fresh weight ratio
- Isotopic discrimination factor
- Water Equivalent of dry matter
- Plant carbon fraction from air
- Plant to shoot yield ratio
- Stable carbon in plant
- Soil-to-plant transfer factor (radionculide-specific)
- Air-to-plant transfer factor (Applicable only for special cases - See Section 6.0)
- Food Processing Factor (radionculide-specific)
- *Input fractions*

4.8.11 Aquatic Animal Blocks

The user can create an *Aquatic Animal* block to represent any non-plant organism found within aquatic environments (i.e. *Water* polygons), such as fish or shellfish. The user must define an *Aquatic Animal* type in the database before the user can create a block of that type in the Scenario.

All but one of the attributes associated with *Aquatic Animal* blocks are global attributes that are defined in the database. The only local attribute is an *Input fractions* data group containing member attributes for each input link to this block. The member attributes contained in the *Input fractions* data group are used to specify the percentage of each exposure medium (eg. water and sediment) which each input link contributes to the aquatic animal.

- Bioconcentration factor (Radionculide-specific)
- Sediment occupancy factor (Not Applicable to DRL calculation)
- Foodchain multiplier (Not Applicable to DRL calculation)
- Risk factor (Small Lake) (Not Applicable to DRL calculation)
- DCF_f (internal) (Not Applicable to DRL calculation)
- DCF_w (water external) (Not Applicable to DRL calculation)
- DCF_s (sediment external) (Not Applicable to DRL calculation)
- Food processing factor (radionculide-specific)
- *Input fractions*

The availability of Input fractions for aquatic animals allows for the representation of instances when fish are only resident in a given water body for a fraction of total time (e.g. migratory salmon found only seasonally near an outfall).

4.8.12 Aquatic Plant Blocks

The user can create an *Aquatic Plant* block to represent any plant found within aquatic environments (i.e. *Water* polygons). In IMPACT, the aquatic plant model is used only for floating or submergent vegetation. *Emergent* aquatic plants (i.e. those with most plant tissue exposed to air, but rooted in wet areas) are represented as terrestrial plants in Land Polygons with links to soil blocks (see Section 4.8.9). The user must define an *Aquatic Plant* type in the database before the user can create a block of that type.

The attributes associated with *Aquatic Plant* blocks are all global attributes are defined in the database.

- Bioaccumulation factor (radionculide-specific)
- Air-to-plant transfer factor (radionculide-specific)
- Food processing factor (radionculide-specific)

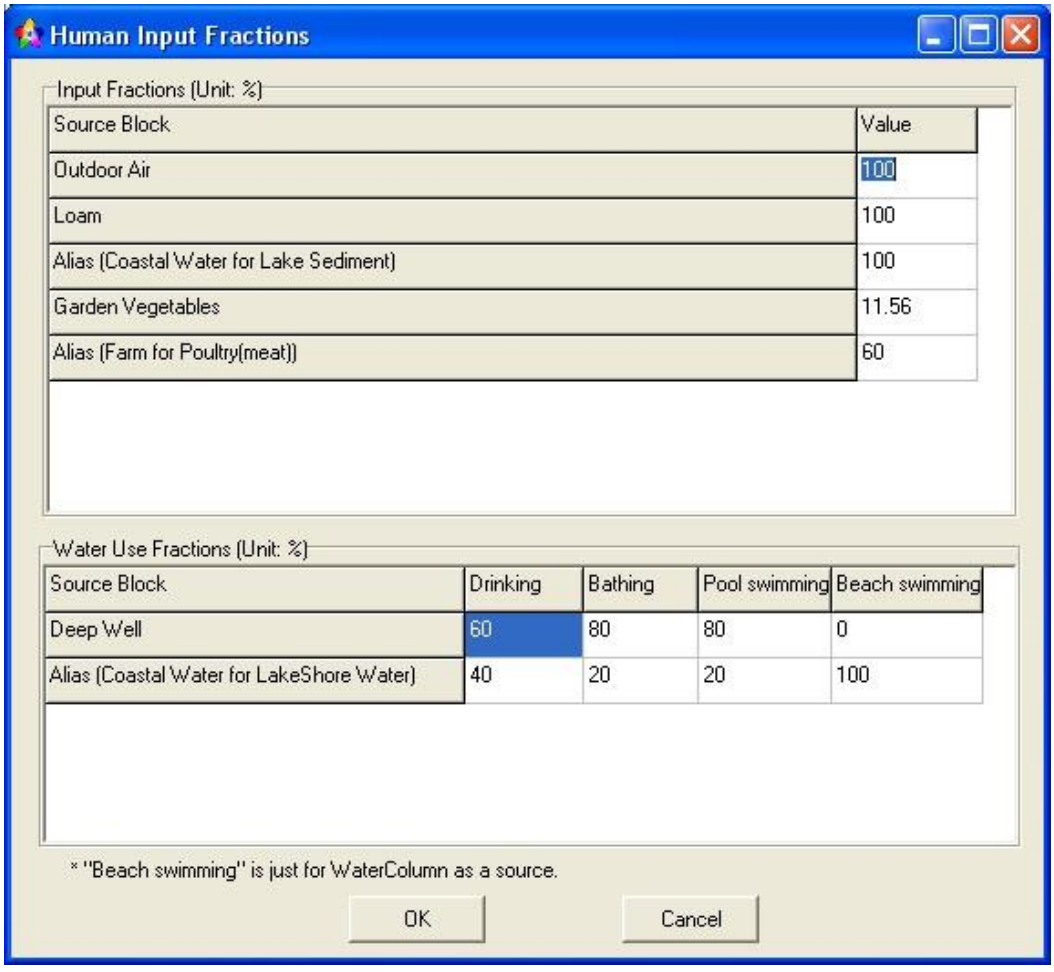
4.8.13 Human Blocks

Human blocks are created to represent any human that resides within a scenario. If the user wishes to represent humans with different physiological responses (e.g. adults vs. infants) or different potentials for exposure to contaminants based on lifestyle or occupation (e.g. mine worker vs. city resident) each must be represented by a different *type* which must be defined within the database. Human blocks are created only in Land Polygons, and can accept inputs from all other block classes except *Source* and *Plume* and can output only to *Monitor* blocks. For this reason, the ingestion of breast milk by human infants should be handled as a special case, using a Terrestrial Animal block to represent the breast milk (see Section 6.0).

Human blocks have the most attributes of any block class. All but one of the attributes are *global* attributes which are defined in the database. The only local attribute is an *Input fractions* where the user specifies the percentage of each exposure medium (eg. air, soil, water, plant food and animal food)which each input link contributes to the human.

- Inhalation
- Inhalation occupancy factor
- Water ingestion rate
- Soil ingestion rate
- Land Plant ingestion rate
- Land Animal ingestion rate
- Aquatic plant ingestion rate
- Aquatic animal ingestion rate
- Outdoor occupancy factor
- Plume shielding factor
- Water exposed area
- Groundshine shielding factor
- Soil reduction factor
- Soil exposed area (Not Applicable to DRL calculation)
- Sediment dilution factor
- Bathing occupancy factor
- Exposure frequency for soil
- Exposure frequency for sediments
- Shoreline occupancy factor
- Pool occupancy factor
- Body mass (Not Applicable to DRL calculation)

- Radiation cancer risk (Not Applicable to DRL calculation)
- DCF_f (ingestion)(radionculide-specific)
- DCF_i (inhalation) (radionculide-specific)
- DCF_a (air external) (radionculide-specific)
- DCF_g (soil external) (radionculide-specific)
- DCF_s (sediment external) (radionculide-specific)
- DCF_w (water external) (radionculide-specific)
- Ingestion risk factor RF_f (radionculide-specific, Not Applicable to DRL calculation)
- Inhalation risk factor RF_i (radionculide-specific, Not Applicable to DRL calculation)
- *Input Fractions*



Note that the *Input Fraction* dialogue for humans distinguishes among the different water exposure pathways, allowing exposure to water from diverse sources (deep wells, shallow wells, lake or pond water)

4.8.14 Source Blocks

Source blocks are used to represent the release of contaminants into the biosphere. There are four (4) types of source blocks that can be created within an IMPACT scenario. The *Point*, *Pond* and *Groundwater* sources are used when the loading rate or concentration of contaminants discharging from the source(s) is known, but the actual concentrations in the receiving media are unknown. A *Dictator* source is used in the case when concentrations in any or all receiving media are known. If the intent of a scenario is to calculate a derived release limit using a DRL Monitor (see Section 5.1.1), the user should not establish any Dictator sources

It is important to note that only single sources are permitted when running simulations in DRL mode. Attempts to run simulations with more than one source established in a scenario will generate a warning message (as depicted below), and the simulation will not proceed

IN DRL MODE, DRL MONITORS (SEE SECTION 4.8.15) ARE DISABLED IF MORE THAN ONE SOURCE OF ANY TYPE IS PRESENT.

All attributes of *Source* blocks are local. The X and Y coordinate attributes are enabled only for *Pointsource*. The X and Y coordiantes can be coordinates in Cartesian system or UTM system.. *Source* blocks do not have an *Input fractions* attribute since they cannot have any inputs.

- *X coordinate*
- *Y coordinate*
- *Contaminants*

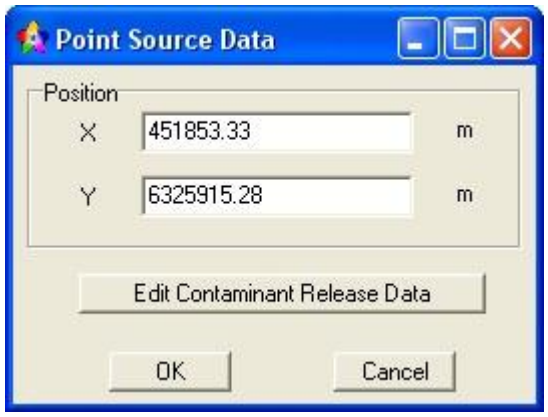
The *Contaminants* attribute is a *data group* that contains the source term data for contaminants that are released from that source. The user can create and edit the source term data as need be (see discussions to follow).

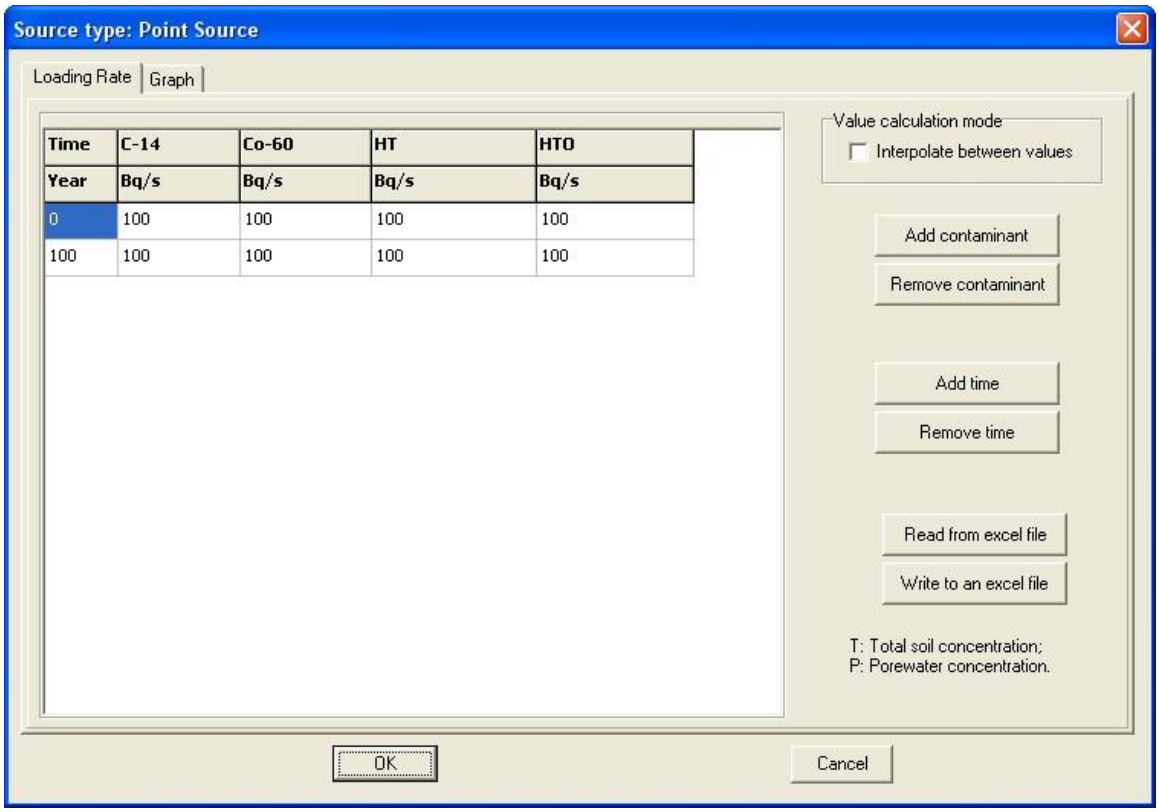
Point Sources

Point Sources are used to represent the release of contaminants to the atmosphere in the form of an airborne plume. A *Point Source* block is used in conjunction with a *Plume* block to represent the airborne plume of

contaminants emanating from the source. Using a reactor stack as an example, the *Point Source* block would represent the stack and the *Plume* block would represent the actual airborne plume of atmospheric emissions that disperses from the stack.

For each *Point Source* created, the user may specify two local attributes; the X-coordinate and the Y-coordinate of the source itself. When the block is created, these values will automatically be set to the respective coordinates of the centroid of the polygon in which the Point source resides. The user can modify these if the user wishes to further define the location of the source within the polygon. To change the X or Y coordinate, double click on the Source icon and enter the desired coordinates in the slots available in the Attribute window. The contaminants and the source terms of the *Point Source* are specified through the standard *Source* dialogue, accessed by clicking the ***Edit Contaminant Release Data*** button.





The coordinates of a Point Source block are used to determine the distance from source to receptor in the atmospheric dispersion model. It is important to take care if the default coordinates are changed for any reason.

Water Sources

Water Source blocks are created within *Water* polygons in order to represent the release of contaminants within the water body itself. This type of source block may be linked to any *Water* block representing surface water (small lakes, rivers, ponds etc.). However, Water source blocks cannot be used to represent contaminant sources discharging to groundwater. This type of release requires a *Groundwater* source block, described below.

To specify the contaminants present in a water source and the release rates of those contaminants, use the standard *Source* dialogue described below.

Groundwater Sources

Groundwater Source blocks are used to represent the release of contaminants to the water table below ground surface. These source blocks are linked directly to *Groundwater* blocks that represent the wells or

aquifers through which contaminated groundwater flows. Groundwater source blocks cannot be linked to Porewater Blocks.

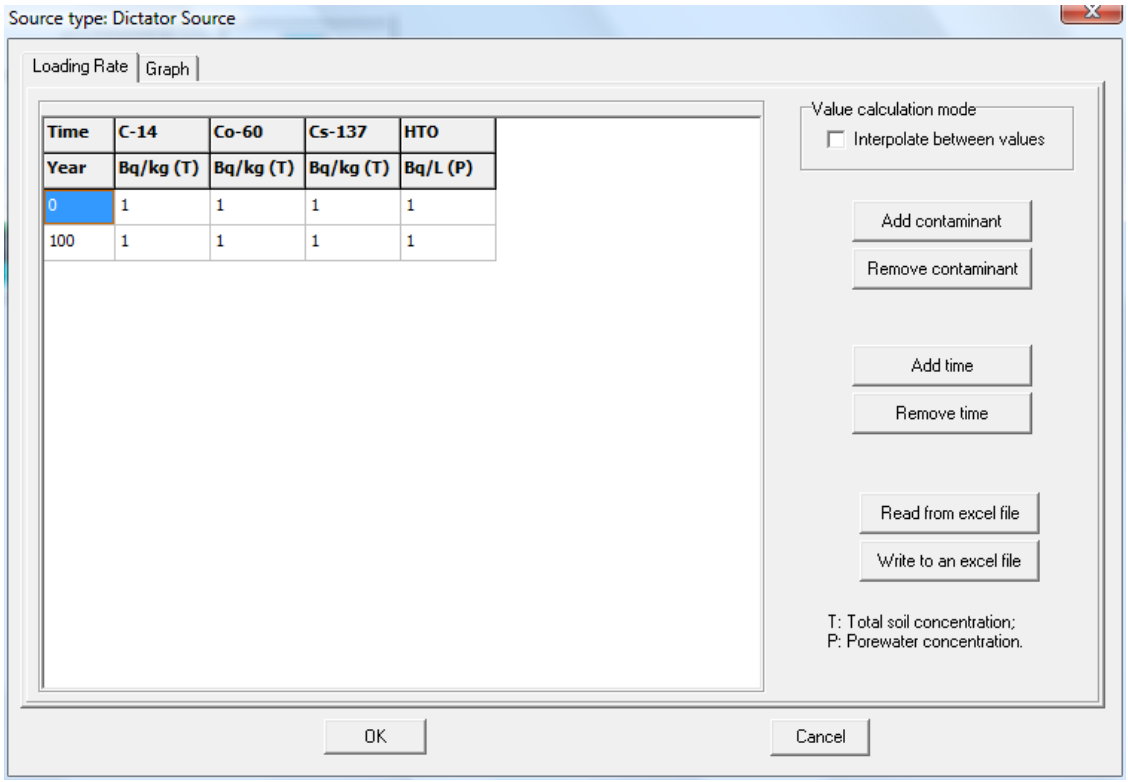
To specify the contaminants present in a groundwater source and the release concentrations of those contaminants, use the standard *Source* dialogue described below

Dictator Sources

A *Dictator Source* block is a special type of source that allows the user to specify measured levels of contamination in several media, including surface water, porewater, groundwater, sediment, soil, air, and all plants and animals. A Dictator source is used in the case when media concentrations are known *a priori*, usually because of the availability of measured values.

The contaminants and the source terms of a Dictator source are specified within the standard Source dialogue using the techniques described below. The only difference with Dictator sources is that the user specifies the concentrations of contaminants in a media rather than a loading rate. This difference is reflected in the units displayed for the concentration attributes.

When a dictator source is linked to a soil block dictating HTO concentration, the HTO concentration is really the soil pore water concentration with a unit of Bq/L. For all other contaminants, the dictated soil concentrations are total soil concentrations that have units of Bq/kg. An example of a dictator source linked to a soil block is shown as follows.



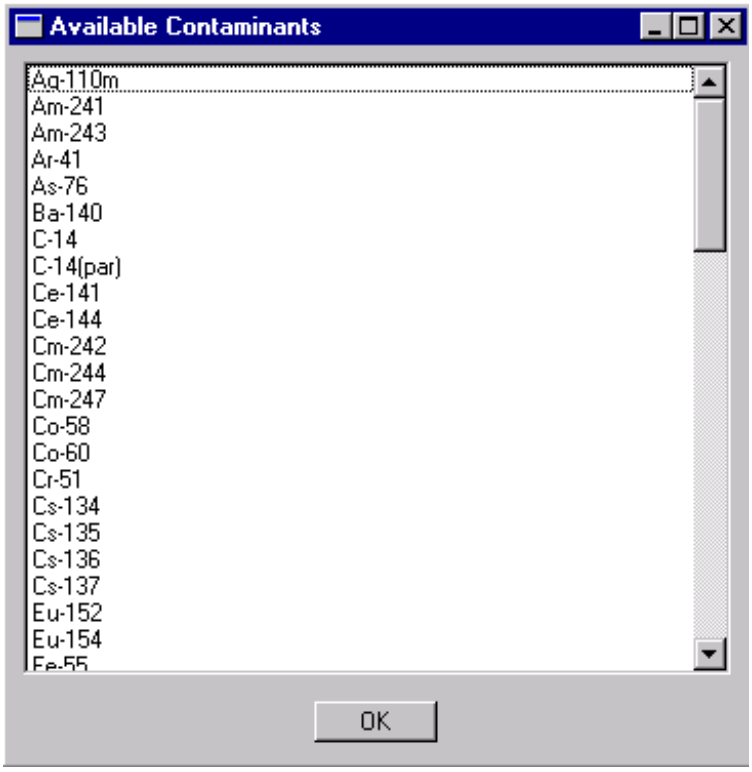
Source Dialogue

For each type of source block that can be created, the user will use the *Source* dialogue, accessed within the *Attributes* window of each source, to specify the levels of contamination emanating from the source. The contents of this dialogue have been briefly described in Section 3.6.1.

The user can examine the attributes of a source by double-clicking on the source block's icon. This will open the source's *Attributes* window (see example on previous page).

Specifying contaminants

For each source the user needs to first specify which contaminants are originating from the source. To add contaminants to a source, click the **Add contaminant** button in the *Source* dialogue. This action will open a new dialogue to present the user with a list of available contaminants that have already been defined in the database (refer to Section 4.6).



Simply click on the desired contaminant(s) (using control-clicking or shift-clicking for multiple selections) to add them to the source.

After clicking the **OK** button, the selected contaminants will now appear in the *Source* dialogue in the scrolling list titled Contaminant(s) in source. To define the release rate of a contaminant from the source, select that contaminant from this scrolling list. The selected contaminant will appear highlighted. The source terms for each phase of release of this contaminant can now be specified. In the *Source* dialogue example shown on the previous page, *Co-60* has been selected in the scrolling list. The source term data

that define the release of *Co-60* from this source are shown graphically in the source function graph to the right, and are summarized in tabular form below.

To remove contaminants from the source, simply select the contaminant(s) in the scrolling list and then click the ***Remove Contaminant*** button.

Adding release data

To add release data for a source, simply click the **add Time** button beside the source data table. The newly added time will appear. The user may create as many times as required for the source and edit these newly added release data directly on the table. Optionally, the source release data can be loaded from a excel file which has the same data layout as shown in the table.

It is important to note that an implicit requirement of operating in DRL mode is that contaminant sources are constant through time. For this reason time varied data are not permitted in any source when in DRL mode. Additionally, the initial loading and any other time loading for any contaminant should be equal. If they are not equal, IMPACT assumes that the initial loading persists throughout the entire duration.

IN DRL MODE, SOURCE TERMS MUST BE CONSTANT THROUGH TIME. IF TIME VARIED LOADINGS ARE SPECIFIED, ONLY THE INITIAL LOADING TAKE EFFECT THROUGHOUT THE ENTIRE DURATION OF THE RUN.

4.8.15 Plume Blocks

A *Plume* block is a special form of block used to mediate the processes of atmospheric and aquatic dispersion of contaminants. To do this, the *Plume* block must receive a link from a *Source* block (i.e. a Point Source or a Pond source).

Atmospheric Plumes

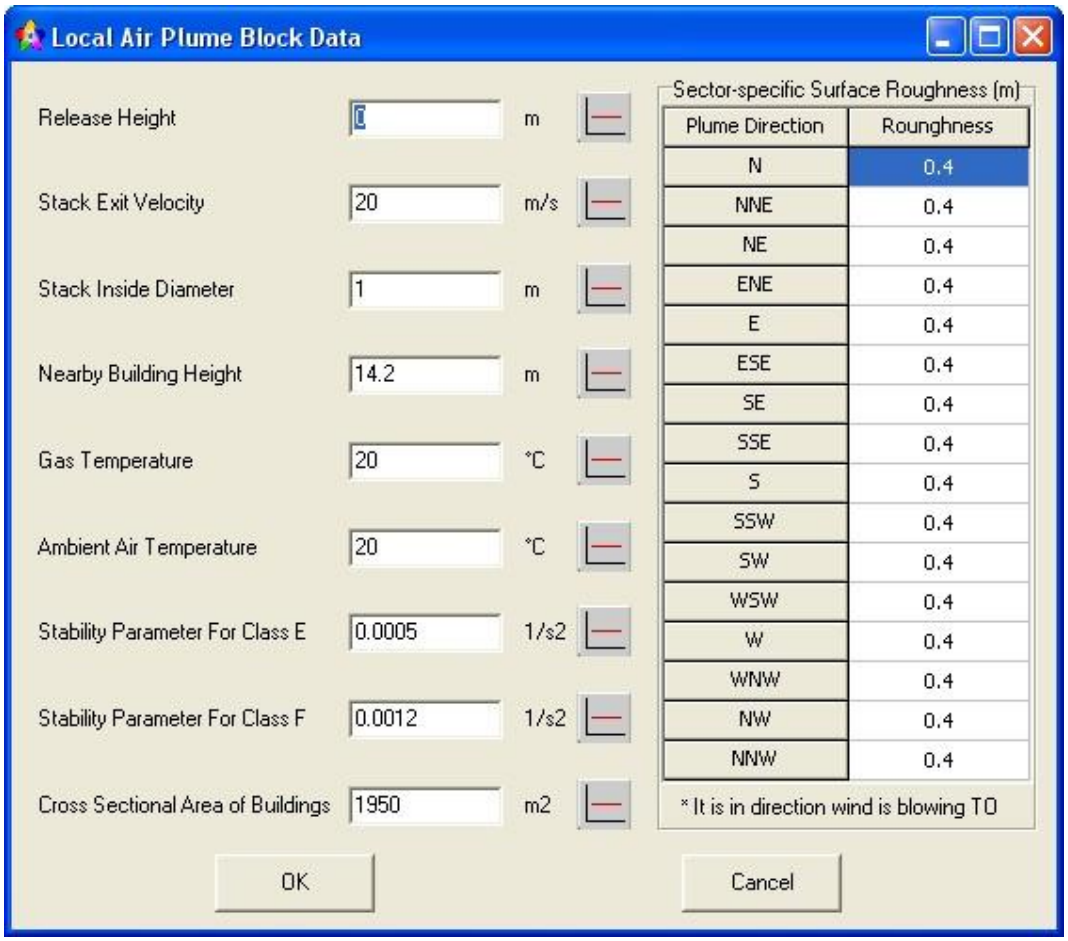
At any Land Polygon, an atmospheric *Plume* Block can be created simply by clicking the **Plume** command in the Polygon menu bar. Only one plume can be created in any given polygon.

In the case of atmospheric dispersion, it is not necessary to link the *Plume* block to any *Air* blocks in a scenario. These links are implicit and are not shown on the screen.

All attributes of atmospheric *Plume* blocks are all local – the user cannot define *Plume* block types in the Database section of a scenario. The attributes are defined within the plume dialogue (accessible by double clicking on the plume block) and include the following:

- *Mixing height*

- *Source height*
- *Surface roughness*
- *Input fractions*
- *Stack Exit Velocity*
- *Stack Inside Diameter*
- *Nearby Building Height*
- *Gas Temperature*
- *Ambient Air Temperature*
- *Cross Sectional Area of Buildings*
- *Sector-specific surface roughness*

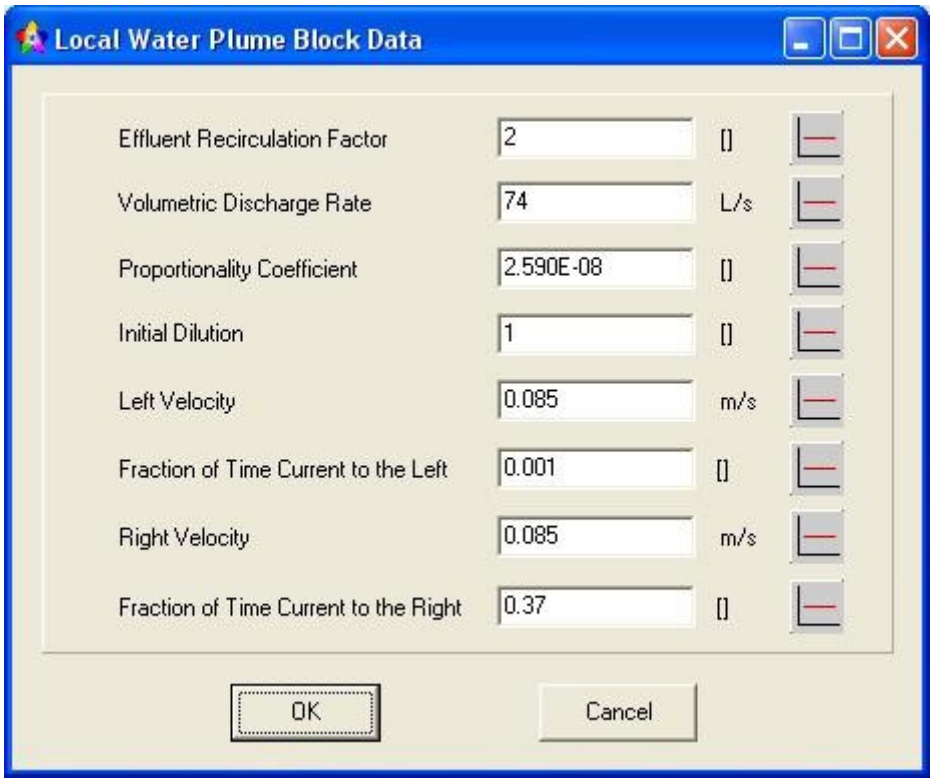


Aquatic Plumes

An aquatic *Plume* Block can be created in any water Polygon by clicking the **Plume** command in the Polygon menu bar. Only one plume can be created in any given water polygon.

Unlike the procedure followed to represent atmospheric dispersion, the aquatic *Plume* block must be linked to a *Coastal Water* Block in order for the dispersion model to be invoked. If the Coastal Water block is in a Water polygon other than that which contains the *Plume* block and the Source block, the link is accomplished through the creation of an *Alias* of the Plume Block. It is permitted to have more than one plume block connected to any single *Coastal Water* Block. The same plume can be linked to a *Coastal Water* block in any or all Water polygons established in the Scenario. All attributes of aquatic *Plume* blocks are all local. The attributes are defined within the plume dialogue (accessible by double clicking on the plume block) and include the following:

- Effluent recirculation factor
- Volumetric discharge rate (of effluent)
- Proportionality Coefficient
- Initial Dilution
- Left Velocity
- Fraction of time current is to the left
- Right Velocity
- Fraction of time current is to the right



For all plume-related attributes, the user can simply enter a fixed value in the appropriate field, or define a PDF using the standard *Parameter* dialogue (see related discussion in Section 4.6.3). All values (distributions or constants) may be referenced in the Parameter dialogue.

The left velocity is the current velocity when the plume is moving to the left, for an observer standing on shore at the source and facing the water. The right velocity is the current velocity when the plume is moving to the right for the same observer.

4.8.16 Monitor Blocks

There are five types of *Monitor* blocks that may be created and linked to other blocks for the purposes of capturing and displaying media concentrations or receptor doses and risks.

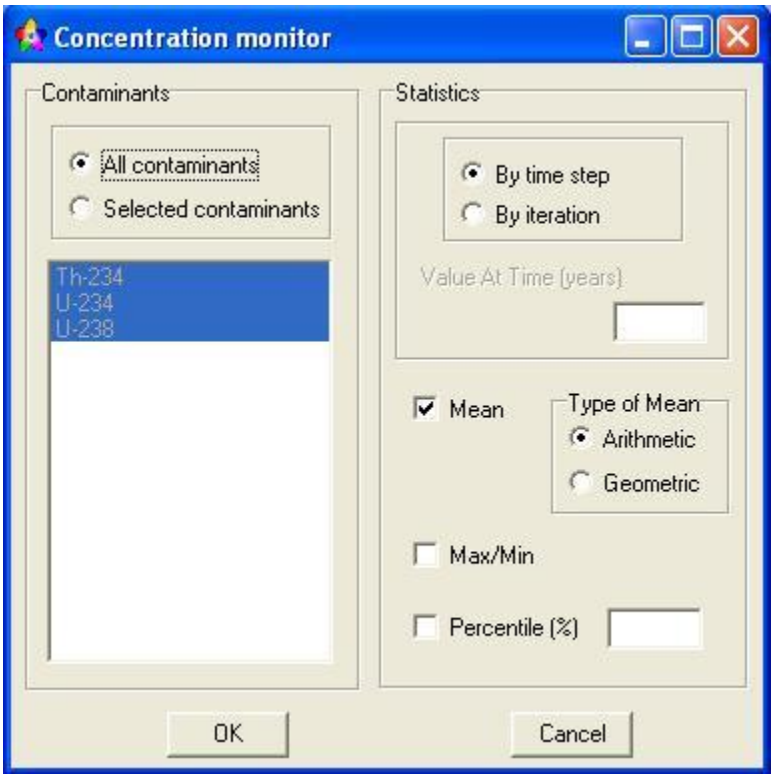
For each *Monitor* block, it is necessary to define what endpoint to monitor (e.g. concentration of selected contaminants, total dose, dose by pathway), when to monitor (by time step or iteration), what statistics to produce (mean, maximum, minimum, percentile), and the type of output desired (files and/or graphs).

To define a *Monitor* block's attributes, double click on its icon and a dialogue will open where the attributes specific to that monitor type can be defined (see various examples below).

Concentration Monitors

Concentration Monitors are created in order to monitor the concentration of one or more contaminants in a single block, except for air blocks, which require their own *Air Monitor*.

Once a *Concentration Monitor* has been created, the user will need to define its attributes. Double-clicking on the *Concentration Monitor* icon will open a dialogue (see examples below) where the user can specify the attributes specific to this monitor.



Selected contaminants

Under the **Contaminants** list, the user has the option of selecting *All contaminants* or *Selected contaminants* simply by clicking the appropriate radio button. In the examples above, the *All contaminants* option has been selected and all of the available contaminants have been selected in the scrolling list. A monitor can be configured to monitor any or all contaminants, as long as they are in the Contaminants database. If the contaminant(s) specified for monitoring are not released from any source, and are not the daughter product of any contaminant that is released from a source in the scenario, then the monitor will simply return a value of zero for that contaminant.

Statistics

Common to most of the dialogues associated with monitor blocks is a group of items labeled Statistics (see the example above). Using the available options, the user can select several statistical options that control the values calculated by the monitor. The default configuration of all newly created Concentration monitors is to produce mean output by time step. This is suitable for deterministic runs. The other statistical options are applicable in instances of probabilistic simulations.

The user can choose between monitoring statistics by time step or by iteration (for probabilistic runs) simply by clicking the appropriate radio button. If *time step* is selected, the user can capture the arithmetic or geometric mean value, or the maximum and minimum values of the output (see the middle column of the table below). The user may choose any or all of these options, by checking the appropriate check box. If the user selects *by iteration*, only the Max/min and Value at time options will be enabled (see the last column of the table below). One or both of these options may be selected by checking the appropriate check box. If the user chooses *Value at time*, the user will need to specify the time period (in years) at which the value is calculated.

To reiterate, most of the statistical options are valid only when running a probabilistic simulation. If the user runs a deterministic simulation (i.e. one iteration only), the only valid statistic will be the mean, which will be equal to the single calculated value.

Option	**by time step (*i*)**	**by iteration (*j*)**
Mean - arithmetic	$\left(V_{i,1}+V_{i,2}+\ldots V_{i,n}\right)/n$	--
Mean - geometric	$\left(V_{i,1}\times V_{i,2}\times\ldots V_{i,n}\right)^{\frac{1}{n}}$	--
Maximum/minimum	$\max\left(V_{i,1},V_{i,2},\ldots V_{i,n}\right)$	$\max\left(V_{1,j},V_{2,j},\ldots V_{m,j}\right)$
	$\min\left(V_{i,1},V_{i,2},\ldots V_{i,n}\right)$,	$\min\left(V_{1,j},V_{2,j},\ldots V_{m,j}\right)$,
Percentile	$M[l]$ and $M[n-l]$, where M is a sorted array of $[V_{i,1},V_{i,2},\ldots V_{i,n}]$, and $V_{i,1}<V_{i,2}\ldots V_{i,n-1}<V_{i,n}$	--
Value at time	--	$V_{t,j}$

Notes:

i = time step #

j = iteration #

k = percentile (5th or 95th = 95)

l = index = $k \div 100 \times n$

m = number of time steps

n = number of iterations

$V_{i,j}$ = value at time step i and iteration j

Dose/Risk Monitors

Dose/Risk Monitors can be linked to animals (terrestrial or aquatic) or humans to calculate the dose or risk to the receptor by one or more contaminants and/or pathways. The context of this Manual is limited to the application of IMPACT for human dose assessments.

Once the user has created a *Dose/Risk Monitor* and linked it to a human block, double clicking on the monitor icon opens the dialogue where the user can specify a number of monitor attributes (see example on following page).

Some technical aspects of dose and risk calculations are provided in Appendix A.

Monitoring Parameters

Under the **Monitoring Parameters** group, the desired option can be selected by clicking the appropriate radio button(s). Depending on the option chosen, scrolling lists may be provided to allow the user to select one or more contaminants or pathways leading to dose or risk.

Total dose

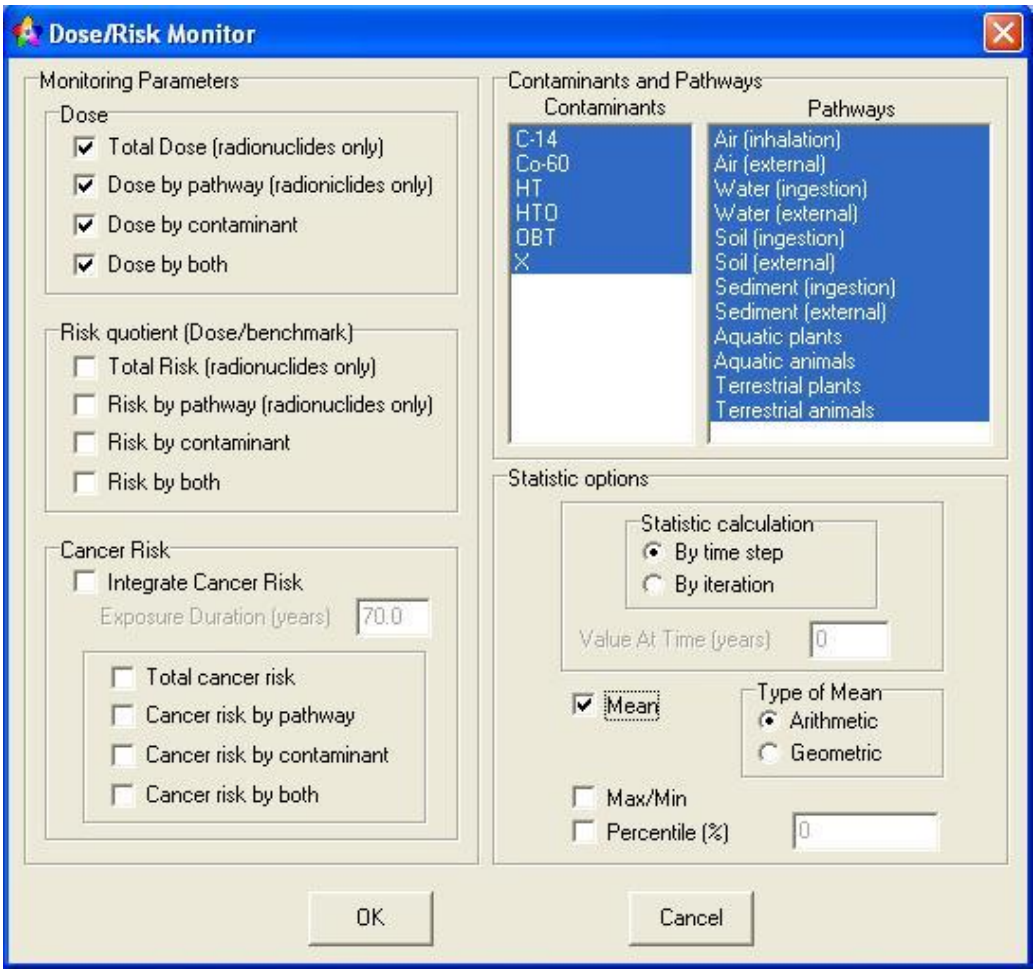
If this option is selected, the total dose to the receptor from all contaminants and pathways combined will be calculated. As noted in the dialogue, it is valid to calculate a total dose only for isotopes. The dose from all other contaminant types will be ignored.

Dose by pathway

If the user chooses Dose by pathway, a Pathway(s) list will appear from which the user can select one or more pathways leading to dose. For each pathway, a dose on encompassing all isotopes will be reported. As noted in the Dialogue, it is valid to calculate dose by pathway only for isotopes. The dose from all other contaminant types will be ignored.

Dose by contaminant

If this option is selected, a Contaminant(s) list will appear from which the user can select one or more contaminants leading to dose. For each contaminant, a dose on encompassing all pathways will be reported. This option is valid for all types of contaminants.



Dose by both

If this option is selected (as in the example above), both a Contaminant and a Pathway list will appear from which the user can select one or more contaminants and pathways leading to dose. For each contaminant, a dose by each pathway is reported. This option is valid for all types of contaminants.

Cancer Risk

The calculation of cancer risk from dose is not implemented in IMPACT 5.4.0.

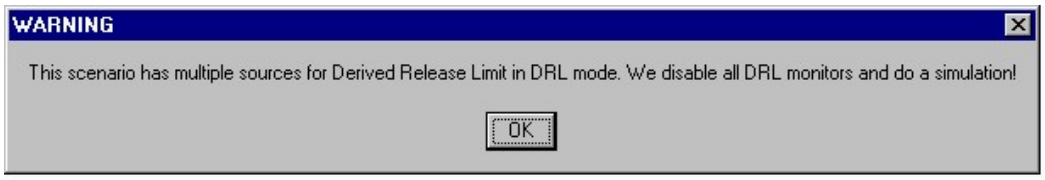
Risk Quotient

The calculation of risk quotients from dose is not implemented in IMPACT 5.4.0.

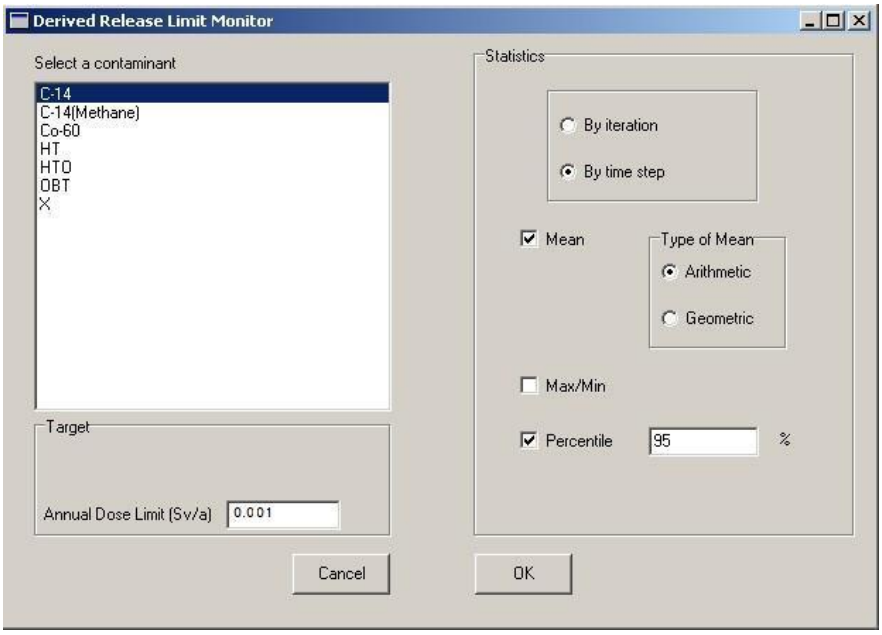
Derived Release Limit (DRL) Monitors

DRL Monitors are created in order to monitor the maximum acceptable emission rate from a single specified source that will result in a specified dose or risk to a human or animal receptor. DRL Monitors are functional only in the DRL Mode of IMPACT

This monitor type can only be linked to a *Human* block. If more than one source exists in a scenario when using a DRL Monitor, an error message will be generated during simulation.



Double clicking on the DRL monitor icon opens a dialogue (see example below) where the user can specify the contaminant, the target dose or risk, and the statistical format of the output to be generated by this monitor.



Selecting contaminants

The DRL monitor dialogue provides a list of all contaminants in the database under the heading Select a single contaminant. From this list, the user can select one contaminant for which the user wants to calculate a DRL. If the user is interested in more than one contaminant, the user will have to produce an output file from this monitor for each contaminant of concern.

The DRL Monitor enables all statistical specifications, assuming that calculations are to be completed in probabilistic mode. In the example appearing above, the DRL monitor has been configured to provide the arithmetic mean and the 95th percentile of the DRL for C-14, assuming an annual dose limit of 0.001 Sv/a. Note that the calculated DRL value accounts for the total dose associated with the release of the specified radionuclide, including doses associated with any of the daughter radionuclides or other metabolites, and including OBT from HTO released.

Annual Dose Limit

In the ***annual dose limit*** field, the user can enter a dose limit that will be used to calculate the DRL. For example, the user could enter an isotope dose target of 1.0E-4 Sv/a (0.1 mSv/a). The DRL calculated by this monitor will be the maximum acceptable emission rate from the source that will result in the specified target dose.

Statistics

Under the Statistics group of items, the user can specify the statistical output options that will be generated by this monitor. These options are common to most monitor types and have been described at the beginning of this Section.

4.8.17 Aliases

An *Alias* block is a block that points to, or is a place-holder for, another block, located in a different polygon. The term *alias* is similar in concept to a *shortcut* in Microsoft Windows® operating systems.

Alias blocks are used as a liaison in creating *links* between blocks that reside in different polygons. They are necessary in order to create links between aquatic and terrestrial blocks, since aquatic blocks cannot be created in *Land* polygons and terrestrial blocks cannot be created in *Water* polygons. Aliases of blocks, however, **can** be cut or copied and placed in any polygon.

Blocks from any database class except *humans* may be aliased. It is also not permitted to make an alias of atmospheric plume blocks and all source blocks. The user creates an *Alias* within a polygon block by first selecting the original block and then choosing the Alias command from the polygon menu bar. The alias is created and placed in the polygon window adjacent to the original block. The user can then cut or copy the alias to the clipboard. From the clipboard the alias can be pasted into any open polygon.

An alias can be linked to another block only as the *upstream* item (i.e. source). An alias cannot be linked as the *downstream* (i.e. receiving) item. Any link between an alias and another block may be created providing that the link between the two block types is valid.

4.9 Manipulating Polygons and Blocks

Once polygons and blocks have been created in a scenario, IMPACT allows the user to modify their shape and location, as well as a number of their attributes. This section describes the procedures to follow to modify any blocks and polygons that have been created.

4.9.1 Selecting Polygons and Blocks

Many editing commands require the user to select a polygon or block before the commands can be carried out (for example, Cut**,** Copy and Delete). To select a polygon or block, simply click on it once with the mouse. The polygon or block will be highlighted to indicate that it is currently selected. A selection is canceled or reversed simply by clicking anywhere outside of the currently selected block's or polygon's boundary.

Multiple blocks can be selected by shift-clicking (holding down the shift key while clicking on several blocks in turn). It is also possible to select all blocks within a specified polygon by choosing the **Select All** command from the **Edit** menu. It is important to note that any action performed subsequent to this will apply to the scenario and can't be redone. Be sure that this is indeed the intention before proceeding. A multiple block selection can be released simply by clicking on a point not occupied by any of the selected items, or by choosing the **Unselect All** command from the **Edit** menu.

4.9.2 Naming Polygons and Blocks

IMPACT assigns default names to polygons and blocks when they are first created. A polygon's default name includes the polygon type ("Land" or "Water") and the polygon's unique ID number. A block's default name is the type ("Poultry", "Adults", "Fish"). If the user creates two blocks of the same type, they will be automatically numbered in sequence ("Fish 1", "Fish 2").

Polygon Names

The user can change a polygon's name by first selecting the *Info* tool from the *Task* window's toolbar and clicking once on the polygon. This will open up the polygon's *Attributes* window, as on the following page. Selecting the slot containing the name (e.g. *Water 1)* will allow the user to simply enter a new name.

Block Names

Block names can be changed either by selecting the block and choosing the **Rename**… command from the menu bar. The Change Name dialogue will be opened where the user can specify the new block name.

The monitor block name is a part of the monitor output file name. Since Windows system doesn't allow some special characters (i.e. "/", "\" etc.) in monitor output file names, it is strongly recommended to use only alphabetic (includes space and underscore etc) and numeric characters to name monitor blocks.

If a monitor block name consists of invalid characters, then IMPACT will still run, and the results for this monitor can only be shown in output graphs. No output file will be produced for this monitor block.

4.9.3 Moving Polygons and Blocks

Moving polygons in the *Biosphere* window is accomplished by first selecting the *Polygon Move Tool*  and then clicking and dragging the polygon to the desired location. An outline of the polygon follows the mouse while dragging to give a visual indication of the new position. After releasing the mouse button,

the polygon is moved to the new location and it is redrawn. Moving polygons in this manner will automatically adjust the X and Y coordinates of the polygon's centroid to the new location.

Be careful when moving polygons - this will reset the polygon coordinates which has implications in the atmospheric dispersion model.

If more than one polygon is selected, clicking on any one of the selected polygons and dragging it will move all of the selected polygons at the same time. This feature is useful for repositioning a number of polygons at once.

Moving blocks is accomplished in the same manner, except that the user does not have to select the *Polygon Move Tool* first – simply select the block (single-click) and drag using the mouse.

4.9.4 Deleting Polygons and Blocks

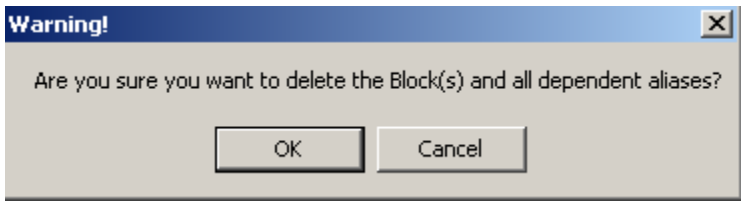
Polygons

The user can delete one or more polygons by selecting them and choosing Clear from the Edit menu. Any blocks contained within a deleted polygon will also be deleted.

Be careful when deleting polygons that contain blocks that have been aliased. Deleting the original block will also delete all aliases of the original block.

Blocks

Blocks are deleted simply by selecting them and choosing **Delete…** from the **Edit** menu. Note that this operation is different from Cut, which removes the selected blocks from the owning polygon and places them on the clipboard. Deleting a block for which aliases have been created will also result in the deletion of the aliases themselves.



When a polygon or block is removed, either by selecting Cut or Clear, any links connected to that polygon or block are also removed.

4.9.5 Editing Polygon Shapes

Once a polygon has been created using any of the techniques described in Section 4.7, there are several techniques that can be used to modify the size, shape and fill patterns of that polygon.

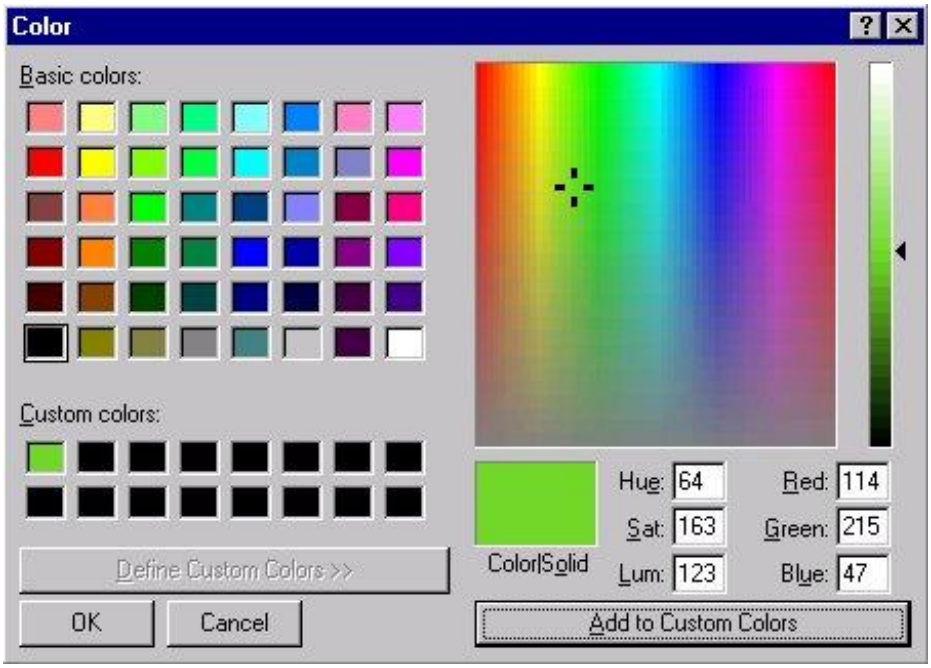
Reshaping Polygons

The user can modify the shape of a polygon after creating it by moving the individual points or *nodes* that make up the polygon's boundary. To reshape a polygon, first select the *Reshape* tool ( ) from the toolbar and then click once on the polygon. A number of square *nodes* will appear around the perimeter of the polygon. With the *Reshape* tool, the user can click and drag individual nodes to a new location. As you drag nodes, the polygon's shape is stretched to give a visual indication of what the new perimeter of the polygon will look like. Reshaping a polygon will affect its area, but the coordinates of the centroid will not be changed. IMPACT recalculates the area for the user automatically when the user reshapes a polygon.

Changing Polygon Fill Patterns

The fill pattern and color of any polygon (land or water) can be customized using the **Fill...** command in the **Polygon** menu. Selecting one or more polygons and choosing this command opens a dialogue (see example below) where the user can specify the color of the currently selected polygon(s).

The Standard colors popup menu in the dialogue is used to select a pre-defined fill color from a list of available colors. The Custom color settings panel can be used to create a custom color by specifying the red, green and blue components of the custom color. The user can increase the amount of each component by clicking on the scrollbars below each. A preview of what the custom color looks like is shown in the Selected color panel.

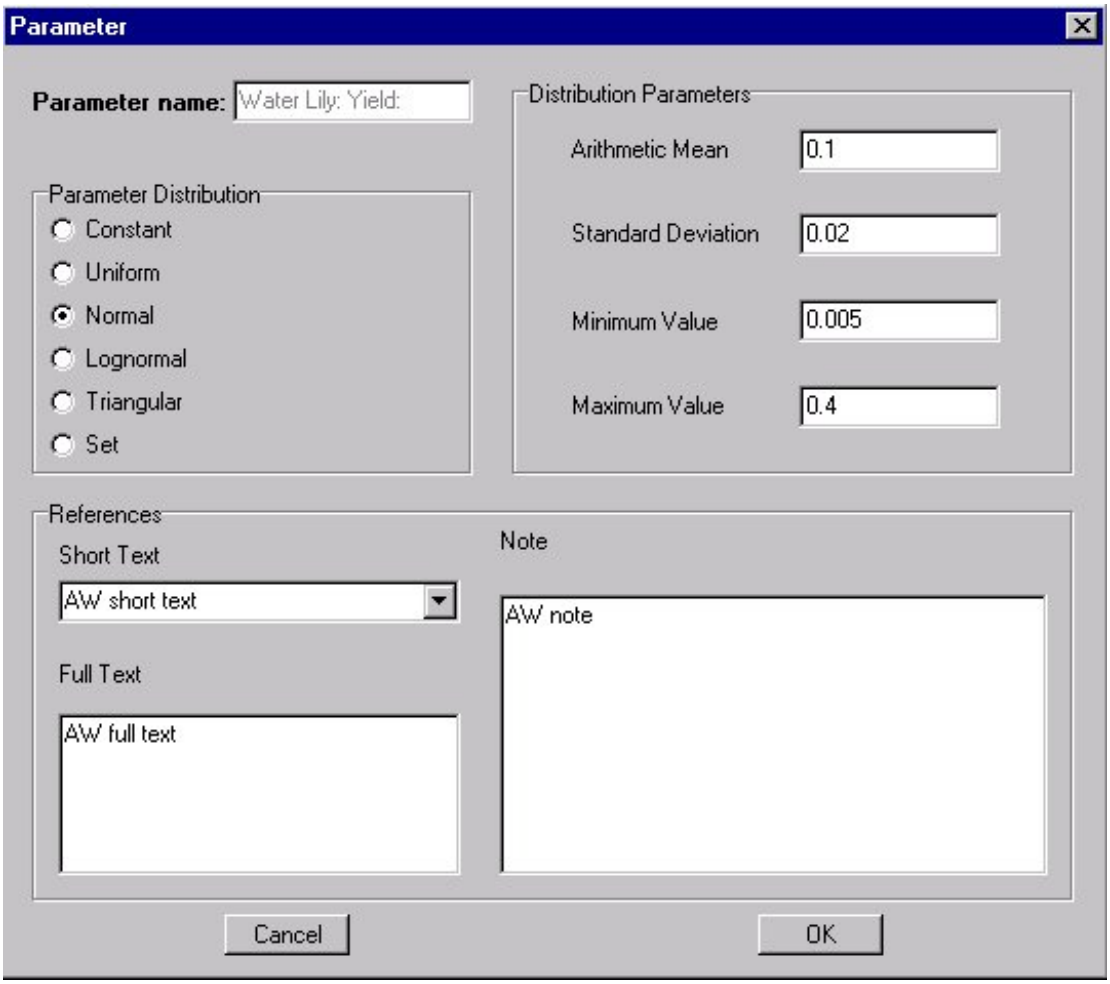


Clicking OK will change the fill color for the selected polygons and close the dialogue.

4.9.6 Editing Polygon and Block Attributes

All attributes for each polygon and block are displayed in an *Attribute* window that belongs specifically to each polygon or block. Fixed value attributes are accommodated with input slots, while attributes which are treated as parameters are displayed with the Parameter icon (). The name of each attribute is listed to the right of the icon, followed by the attribute's value and units, if appropriate. Some attributes are *data groups* that themselves have more than one attribute. These data groups are used to define complex attributes of a polygon or block that cannot be described with just a single value. Examples of attribute data groups are a polygon's *Baseline inflow*, and a Source block's *Contaminants*.

To change the value of an attribute, simply click on its field and text edit. Each type of attribute has its own dialogue for changing the attribute value and assigning a reference and note. The example shown below is the dialogue for editing *parameters*.



The procedures associated with editing attributes have been discussed previously in Section 4.5.2.

Polygons

To open a polygon's *Attribute* window, select the polygon and choose **Attributes**… from the **Edit** menu, or simply click on the polygon of interest with the Attributes tool ( ).

Polygons have a number of attributes that the user may edit within the *Attribute* window. These attributes and the procedures for modifying their values have been described in Section 4.7.3.

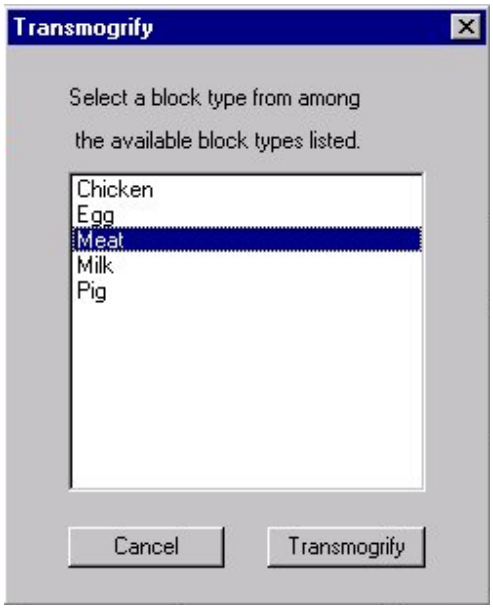
Blocks

To open a block's *Attribute* window, double-click on the block. For those blocks that are characterized by one or more local attributes, a dialogue box will then open. For blocks with no definable local attributes, a message will appear indicating that there are no local attributes, and prompting the user to access the database to modify global attributes. These attributes are summarized in Section 4.8.

4.9.7 Transmogrifying Blocks

The **Transmogrify** command enables the user to change the *type* (not the *class*) of a block that has already been created. For example, if the user created a *Terrestrial Animal* block of type *Dairy Cow* and later decided the user wanted to make it *a Beef Cow*, the user could achieve this using the Transmogrify command.

The command is accessed by first selecting a single block and then choosing **Transmogrify**... from the menu bar in the Polygon window. This action will open the *Transmogrify* dialogue (see example below). The contents of the *Transmogrify* dialogue have been reviewed in Section 3.6.6.



In the example above, a *Terrestrial Animal* block is being transmogrified from its original type of *chicken* to the new type *Meat*. Changing a block's type changes the global attributes and icon for that block, but not the local attributes.

Limitations

Not all blocks in an IMPACT scenario can be transmogrified. *Monitor, Source, Plume* and *Group* blocks cannot be transmogrified. Attempts to transmogrify blocks of these types will yield an error message.

Also, the **Transmogrify** command can only be applied to one block at a time. Multiple selections cannot be transmogrified.

If the user wishes to change the block type of an *alias*, the user must transmogrify the original block rather than the alias itself.

4.9.8 Copying and Pasting Blocks and Links

The **Copy**, **Paste blocks** and **Paste blocks and links** commands in the polygon window under **Edit** menu give options to copy and paste blocks and links from one polygon to another. It is very useful to create polygons with similar blocks and links between them. **Paste blocks** only pastes the copied blocks into the new open polygon, while **Paste blocks and links** pastes blocks and links among blocks into the open polygon with all input fractions unchanged.

When a number of blocks are pasted into a polygon, only those valid blocks can be pasted into the polygon. The valid blocks are defined as follows:

- Blocks are allowed to be existing in the target polygon (i.e. an outdoor air block can exist in both water and land polygons, then it can be copied and pasted from a water polygon to a land polygon. A fish can only exist in a water polygon, it becomes invalid when it is copied and pasted into a land polygon.);
- Blocks that don't have identical names to any blocks in the target polygon.

When pasting selected blocks and links, only the links that connect those copied and pasted blocks are pasted. Links to existing blocks in the target polygon are not automatically established. If a copied block has the same name as an existing block, the copied block gets renamed.

4.10 Linking Polygons and Blocks

Links represent specific processes that may result in contaminant transfer between polygons and between blocks (e.g. ingestion, inhalation, uptake through roots, lake-to-lake flow, etc.). When referring to links, the polygon or block where the link originates is referred to as being *upstream* while the receiving polygon or block is referred to as being *downstream*. The processes that each link represents are context-sensitive, in that they depend on the types of blocks that are linked.

Links are displayed on-screen as a line connecting two polygons or blocks, with an arrow-head pointing in the downstream direction of contaminant movement. Some links are shown with a double arrow-head indicating that the link is *two-way* (i.e. contaminants can move in both directions). An example of a *two-way* link is a link between an *Air* and *Soil* block, which represents both settling of dust from air to soil, as well as the re-suspension of dust from soil back to air. Two-way links are not permitted in DRL mode as they give rise to circular pathways.

IMPACT will not let the user make a link that doesn't make sense. For example, a link between an *Air* block and a *Sediment* block would not be permitted, since this pathway cannot be modeled in IMPACT. If the user tries to create an invalid link, the user will get an error message.

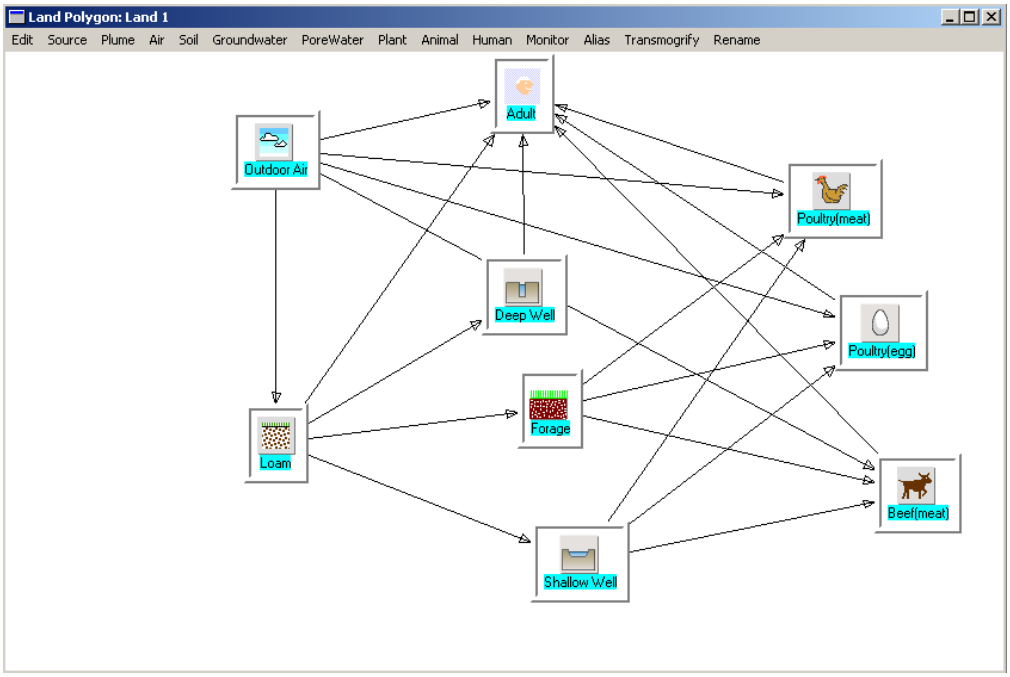
4.10.1 Implicit Links

There are links that are created for the user automatically by IMPACT that the user does not have control over. There is an *implicit* link between a *Plume* block and all *Outdoor Air* blocks in a scenario. These links are called *implicit*, since IMPACT creates them for the user automatically and does not display them on-screen. There is also an implicit link between a Porewater Block and Groundwater Block found in the same polygon, as long as the groundwater is linked to the soil. All other links are created explicitly by the user, following the techniques described in this section.

4.10.2 User-defined Links

To create a link, first select the upstream polygon or block where the contaminants originate. Then click once on the downstream or receiving polygon or block while holding down the control key. This will create a link from the upstream polygon or block to the downstream polygon or block. If the *Show Links* option has been selected in the **View** menu, the links between polygons (if any) will be drawn on-screen. For most purposes within the DRL context of this Manual, links between polygons will not be required. Typically, polygon-to-polygon links would only be used to establish erosional transport or to create a chain-lakes scenario.

In some cases, it is desirable to have more than one polygon or block of a single type linked to another polygon or block. For example, a potential receptor, represented by a *Human* block may consume beef, pork, chicken and milk. In this case, four separate *Terrestrial Animal* blocks must be connected to the *Human* block, as depicted in the following example.



4.10.3 Specifying Input and Output Fractions

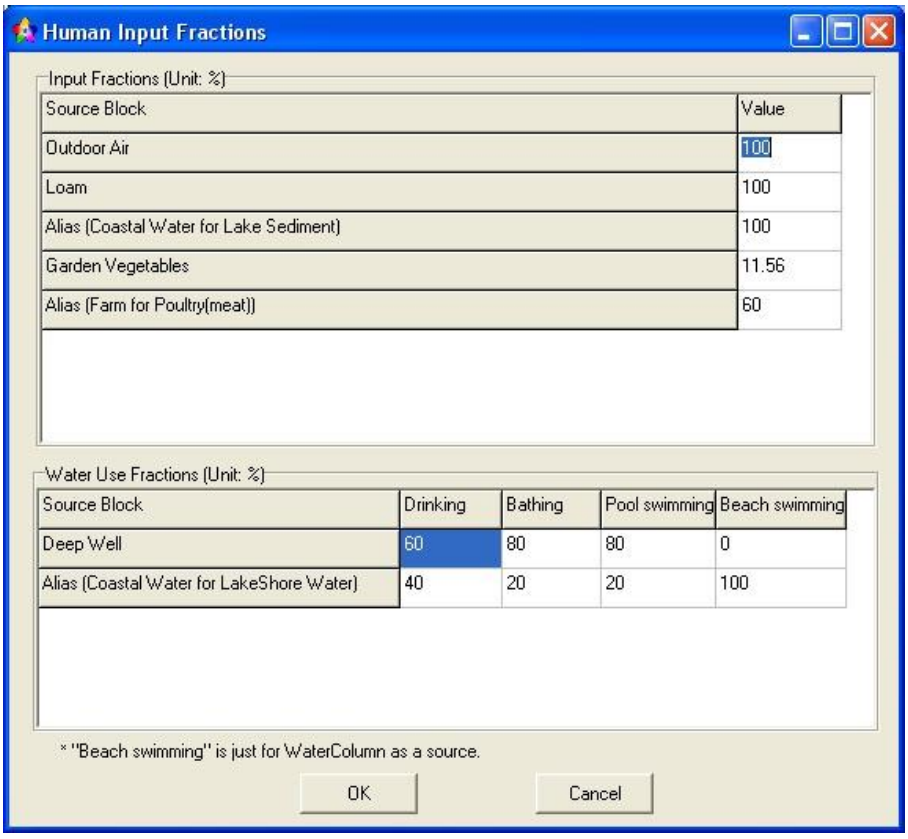
Polygons

All polygons have an *Output fractions* data group containing attributes (members) that define the fraction of the total runoff (Land) or outflow (Water) leaving the polygon that enters each receiving polygon. The user can specify the output fractions for each receiving polygon by modifying the member attributes in a polygon's *Output fractions* data group. Polygon-to-polygon links are not relevant to the scope of this Manual.

Blocks

Some blocks have an *Input fractions* data group containing attributes (members) that define the fraction of the total input of that medium that is received from each input block. The user can specify the input fractions for each input block by modifying the member attributes in a block's *Input fractions* data group.

Refer to the example of the *Human* eating four different animal types in the previous section. After the user has linked each *Terrestrial Animal* block to the *Human* block, the user must specify the relative percent contribution of each animal to the total amount of terrestrial animal produce ingested by the human. To do this, the user must edit the *Input fractions* attribute of the *Adult* block by double-clicking on the *Adult* block icon and expanding the *Input fractions* data group in the *Adult* block's *Attribute* window (depicted below).



Initially, all input fractions are assigned a value of 100%. The user only needs to edit the members if the user wants the input fraction to be other than 100% (in this case, the input fractions for animal products).

For the example described above, the user would specify the percent of terrestrial animal intake (usually by weight) for each type of animal consumed by the human receptor. If the *Resident* consumed a total of 100 kg of animal produce per year, which was made up of 22 kg beef, 30 kg eggs, and 5 kg poultry, the relative percent specified for each attribute in the human's *Input fractions* would be: beef 22%; eggs 30%; and chicken 5%. Note that the dialogue does allow the total of all inputs to exceed 100%. The user should modify the values so that totals do not exceed 100% for air, soil, plant produce or animal produce.

Similary, the sum of percentage contributions from different water sources should not exceed 100% for each water use, such as drinking.

The total amount of all terrestrial animal produce consumed in one year (100 kg) would be specified for the *Animal ingestion* global attribute for the Human *Adult* type.

4.10.4 Removing Links

Removing a link between blocks in the same manner as creating a link: click once on the upstream polygon or block and control-click on the downstream polygon or block.

When a polygon or block is removed, either by selecting **Cut** or **Delete** commands in the **Edit** menu, any links connecting that block or polygon to another are also removed.

4.10.5 Link Limitations

The user will not be able to create a link between certain combinations of blocks (e.g. linking an *Aquatic Animal* to *Air*). There are some links that may seem logical but are not allowed. However, there is usually a simple way to represent the desired process.

Linking terrestrial and aquatic blocks may seem to be impossible, since these blocks cannot coexist in one polygon. The user can make these types of links, however, by using an *Alias* block. *Alias* blocks serve as pointers or place-holders to other blocks, and can reside in any polygon. The use of *Alias* blocks is described in detail in Section 4.8.16.

In DRL mode, any combination of links that gives rise to a circular pathway will result in a warning message at the onset of any simulation, and the simulation will not be completed.

IMPACT will also provide a message that identifies the location of the circular pathway.

The various links that are allowed in IMPACT, the processes that they represent, and specific considerations are summarized in the following Table.

Summary of Transfer Parameters and Representative Links

Transfer Process	Required Link(s)		Relevant Model Input[1]	Other Notes
	From	To		
P_{01} Atmospheric Dispersion[2]	Atmospheric Plume Block	Outdoor Air Block	Plume block local attributes, Meteorological Dialogue (wind data)	Link to all air blocks in scenario is implicit. Atmospheric dispersion will account for ingrowth if Global Reactions are defined.
P_{11a} Oxidation of HT to HTO in soil, and re-emission to air	NA	NA	Outdoor Air block global attributes	These two processes are implicit and are calculated without any required links. Need to adhere to Contaminant Naming Constraints (see Section 4.5.1)
P_{11b} Oxidation of C-14 (methane) to C-14 (carbon dioxide) in soil, and re-emission to air	NA	NA	Outdoor Air block global attributes	
P_{31} Volatilization from soil to air	Soil Block	Outdoor Air Block	Outdoor Air block global attributes, Soil block global attributes and local attributes (i.e. irrigation rate)	In DRL mode, this pathway can only be considered when assessing a release to water, otherwise circular pathways are likely to arise
P_{12} Deposition from air to pond	Outdoor Air Block	Pond Block	Contaminant Global Attributes (settling velocity and washout ratio), Meteorological Dialogue (precipitation), Water Polygon Local Attributes (area), Pond Block Global Attributes	The resulting contaminant concentration in soil is handled and expressed in IMPACT on a mass basis (as opposed to an area basis).
P_{13} Deposition from air to soil	Outdoor Air Block	Soil Block	Contaminant Global Attributes (settling velocity and washout ratio), Meteorological Dialogue (precipitation), Soil Global Attributes	The resulting contaminant concentration in soil is handled and expressed in IMPACT on a mass basis (as opposed to an area basis).

Transfer Process		Required Link(s)		Relevant Model Input[1]	Other Notes
		From	To		
P_{13spw}	Deposition from atmosphere to porewater	Outdoor Air Block	Porewater Block	Contaminant Global Attributes (settling velocity and washout ratio), Meteorological Dialogue (precipitation), Soil Global Attributes	Porewater is used to represent shallow wells
P_{14}	Deposition from atmosphere to plants, and direct intake of gases or vapours from air into plant tissues through respiration	Outdoor Air Block	Terrestrial Plant Block	Contaminant Global Attributes (settling velocity and washout ratio), Meteorological Dialogue (precipitation), Plant Global Attributes	Respiration intake can be accommodated, but is not directly considered in the current Guidance for calculating radiation dose or DRL
P_{15}	Transfer from air to animal tissues via Inhalation	Outdoor Air Block	Terrestrial Animal Block	Contaminant Global Attributes (settling velocity and washout ratio), Meteorological Dialogue (precipitation), Animal Global and Local Attributes	Tritium (HTO) is handled as a special case, and the inhalation transfer factor for tritium should be set to 0, except in special cases (e.g. breast milk).
$P_{(i)19}$	Exposure of humans to air due to inhalation	Outdoor Air Block	Human Block	Human Block Global and Local attributes	
$P_{(e)19}$	Exposure of humans to air due to immersion				

Transfer Process	Required Link(s)		Relevant Model Input[1]	Other Notes
	From	To		
P_{02} Aquatic Dispersion[2]	Aquatic Plume Block	Coastal Water Block	Global attributes of the Coastal Water Block, and local attributes of both respective blocks	Aquatic dispersion will account for ingrowth if Global Reactions are defined.
P_{33spw} Transfer from soil to soil porewater	Soil Block	Porewater Block	Global attributes of both respective blocks	Porewater is used to represent shallow wells
P_{3spw2w} Transfer from porewater to groundwater (via infiltration)	Groundwater Block	Pond Block	Global attributes of both respective blocks, and local attributes of the Groundwater block and the Water Polygon	Groundwater is used to represent deep wells
P_{3spw2p} Transfer from porewater to pond water (via shallow subsurface flow)	Porewater Block	Pond Block	Global attributes of both respective blocks, and local attributes of the Water Polygon	
P_{32p} Soil to pond water transfer	see P_{33spw} and P_{3spw2p}	see P_{33spwG} and $P_{G3spw2p}$	see P_{33spw} and P_{3spw2p}	Achieved through two-step process: P_{33spw} and P_{3spw2p}
P_{32w} Soil to groundwater transfer	see P_{33spw} and P_{3spw2w}	see P_{33spw} and P_{3spw2w}	see P_{33spw} and P_{3spw2w}	Achieved through two-step process: P_{33spw} and P_{3spw2w}

Transfer Process	Required Link(s)		Relevant Model Input[1]	Other Notes
	From	To		
P_{23} Transfer from surface water to soil, via irrigation	Pond, Coastal Water, Porewater, or Groundwater Block	Surface Soil	Global attributes and local attribute (irrigation rate) of the Soil Block	To avoid circular pathways, this transfer process is only applicable for a release to water in DRL mode. The calculation is mass based.
P_{24} Transfer from surface water to plants, via irrigation	Pond, Coastal Water, Porewater, or Groundwater Block	Terrestrial Plant Block	Global attributes and local attributes (input fractions for the water sources) of the Terrestrial Plant block, Local attribute of the Land Polygon (Area)	Note that Land Polygon area does play a role, and should be assigned a reasonable value.
P_{25} Transfer from surface water to land animals, via drinking water ingestion	Pond, Coastal Water, Porewater, or Groundwater Block	Terrestrial Animal Block	Global attributes and local attributes (input fractions for the water sources) of the Terrestrial Animal block.	
P_{26} Transfer from surface water to fish via bioaccumulation	Pond or Coastal Water Block	Aquatic Animal Block	Global attributes and local attributes (input fractions) of Aquatic Animal block.	Input fractions for the Aquatic Animal are permitted to account for variable residency in a specified Polygon
P_{27} Transfer from surface water to aquatic plants via bioaccumulation	Pond or Coastal Water Block	Aquatic Plant Block	Global attributes of Aquatic Plant block.	

Transfer Process		Required Link(s)		Relevant Model Input[1]	Other Notes
		From	To		
P_{28}	Transfer from surface water to sediment	Pond or Coastal Water Block	Sediment Block	Global attributes of the Sediment Block	
$P_{(i)29}$	Human dose due to ingestion of water	Pond, Coastal Water, Porewater, or Groundwater Block	Human Block	Global and local attributes of the Human block	Multiple water sources can be used. The model distinguishes between bathing, pool swimming and beach swimming, and input factors need to be defined accordingly. *Aliases* are required to achieve necessary linkage.
$P_{(e)29}$	Human dose due to immersion in water (swimming, bathing)				
P_{34}	Transfer from soil to plant tissues (via root uptake)	Soil Block	Terrestrial Plant Block	Global attributes of the Terrestrial Plant Block	
P_{35}	Transfer from soil to animals (or animal products), via ingestion	Soil Block	Terrestrial Animal Block	Global attributes and local attributes (input fraction) of the Terrestrial Animal Block	The soil ingestion rate defined for each animal block should equal the TOTAL intake (incidental soil intake and soil adhering to food).

Transfer Process		Required Link(s)		Relevant Model Input[1]	Other Notes
		From	To		
$P_{(i)39}$	Human dose due to soil ingestion	Soil Block	Human Block	Global and local attributes of the Human block	A human within any polygon can be exposed to soil in other polygons (accomplished using the *Alias* function)
$P_{(e)39}$	Human dose due to groundshine				
P_{45}	Transfer from plant tissues to animals (or animal products), via ingestion	Terrestrial Plant Block	Terrestrial Animal Block	Global and local attributes of the Terrestrial Animal block, and select global attributes of the Plant Block	Honey is considered as a special case of a Terrestrial animal block in consideration of this transfer process.

Transfer Process		Required Link(s)		Relevant Model Input[1]	Other Notes
		From	To		
P_{49}	Dose to humans due to ingestion of land plant products	Terrestrial Plant Block	Human Block	Global and local attributes of the Human block	A human within any polygon can obtain food products from other polygons (accomplished using the *Alias* function)
P_{59}	Dose to humans due to ingestion of land animal products (meat, milk, eggs, etc.)	Terrestrial Animal Block			
P_{69}	Dose to humans due to ingestion of aquatic animals (fish, shellfish)	Aquatic Animal Block			These transfer processes necessitate the use of the Alias function.
P_{79}	Dose to humans due to ingestion of aquatic plants (wild rice, dulse, etc.)	Aquatic Plant Block			
$P_{(i)89}$	Dose to humans due to incidental sediment ingestion	Sediment Block			
$P_{(e)89}$	Dose to humans due to Beachshine				

Transfer Process		Required Link(s)		Relevant Model Input[1]	Other Notes
		From	To		
P_{9m9}	Ingestion of breast milk by an infant	Terrestrial Animal Block			A nursing infant is treated as a special case, and a Terrestrial Animal block is used to represent the breast milk (see Section

1 -The transfer models for air, water, soil, sediment, and plants can accommodate radioactive decay, and thus Global Reaction data becomes required input.

2- Aquatic and atmospheric dispersion processes necessitate the creation of a Point Source or Pond linked to the Atmospheric Plume and Aquatic Plume Blocks, respectively.

4.11 Exporting

IMPACT allows the user to export graphic information for processing with other applications. The exported file will consist simply of a graphic image of the scenario. This file will contain any background map image the user may have imported, as well as the polygon outlines for the entire modeled area, not just the portion that is visible in the *Biosphere* window. This file can be opened using a variety of graphics programs and web browsers for further editing and viewing.

When the user chooses **Export** from the **File** menu while in the Biosphere window, the user will be presented with the standard *Save As* dialogue asking the user where to put the exported file. The exporting Image file name needs to have a standard extension (e.g .bmp, .jpg) to complete the exporting. The appearance of the Save As dialogue will differ depending on the operating system in use.

OUTPUTS

5.1 Specifying Output

For each simulation to be run, the user will need to specify exactly what it is that they wish to produce in terms of output. This requires that the user specify variables such as contaminants, target media (e.g. air, water, humans, animals, plants), desired end-points or effects (e.g. concentration, dose, DRL), and the format (files, graphs, or summary Tables) of the desired output.

Most of these options are specified when the user creates and configures the monitor blocks in a scenario. The remaining options are specified by selecting commands in the **Simulate…** menu.

5.1.1 Setting Up Monitor Blocks

All output produced from an IMPACT simulation is produced by *Monitor* Blocks. All files and graphs produced during a simulation are based on the attributes of the monitor blocks that the user creates and links to other blocks in the scenario. The user cannot produce output without specifying a monitor from which to derive the requested output data. This includes the output of Summary Tables.

Specifying Environmental Media

In order to select the media for which the user wishes to produce output, the user must establish the appropriate monitor blocks and link them to the blocks that represent the media of interest. These monitors will later be selected as sources of data for files or graphs when running a simulation.

The following table presents a summary of the monitor types that the user will need to create in order to monitor end-points in specified media.

What to Monitor	Type of Monitor Block Required
concentration of a contaminant in any block	Concentration
dose to a human (or animal) receptor	Dose/Risk
derived release limit (DRL) from a source for a specific receptor (human)	DRL

Each of the available monitor types and the procedures for creating them have been described in Section 4.8.16.

Specifying contaminants

Assuming that *Source* blocks containing the appropriate contaminants have been created within the scenario, the process of choosing contaminants for which to generate output is accomplished by selecting the contaminants of interest in a monitor's dialogue. Most monitors allow the user to select one or more contaminants to monitor from a scrolling list of all contaminants that have been defined in the database. Note that a contaminant will be included in this list even if it has not been added to any *Source* blocks. If you select a contaminant that is not present in any source, its concentration or associated dose will be zero.

The manner in which contaminants are specified as attributes of monitor blocks has been fully described in Section 4.8.16.

Specifying endpoints

By modifying certain attributes of monitor blocks, the user can specify the endpoints for a monitor's calculations. Most monitors give the user a choice of the endpoint to be calculated. For example, a *Dose/Risk* monitor allows the user to choose from ten different dose and risk options, such as *Dose by contaminant or dose by pathway*. Section 4.8.16 provides a full description of the endpoints of all monitor types and the means by which they may be modified.

5.1.2 Selecting Monitors for Output

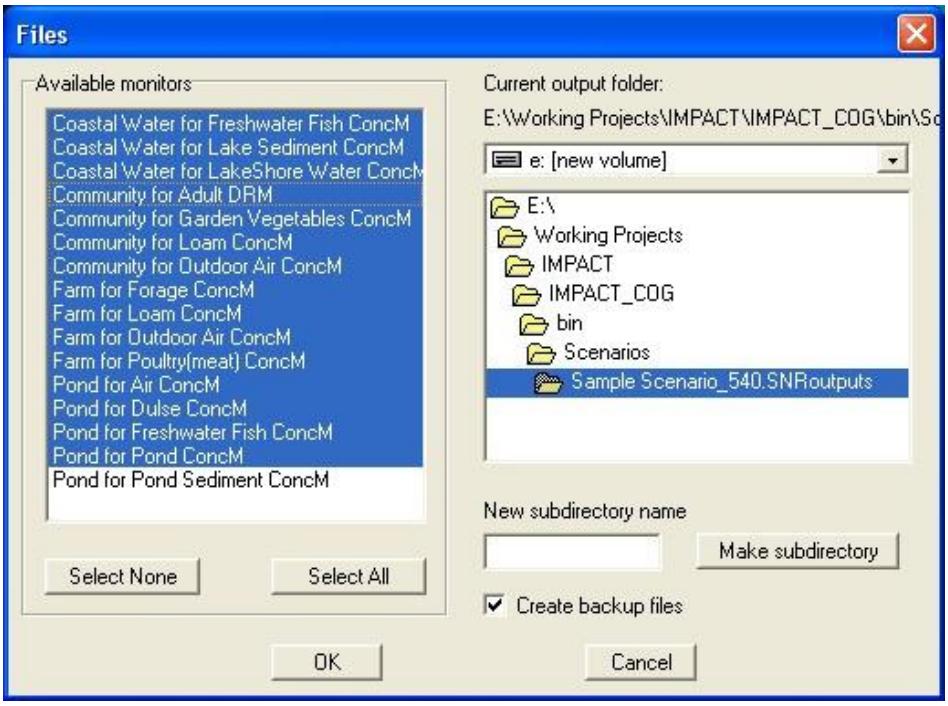
Every monitor block in a scenario can be selected to produce one or more types of output, including the following:

- a text file with monitored values reported at each time step or iteration;
- a graph created automatically while the simulation runs with monitored values reported at each time step or iteration;

Each monitor can produce either graphic or tabular output.

Files

The user can specify which monitors will send their output to text files by choosing **Files**… from the **Simulate** menu. The user can also click on the Files button in the *Run* dialogue. Both actions will open the *Files* dialogue, as depicted in the following example.



Selecting Monitors

The user can specify the monitors to send their output to a text file by selecting the name of the monitor in the scrolling list. Individual monitors can be selected by single-clicking. Shift-clicking creates a continuous selection, while control-clicking allows a discontinuous selection of multiple monitors. Clicking the Select All or Select None buttons selects all or none of the monitors in the list.

Output folder

Normally, output files are placed in the same folder as the scenario file. It is a good idea to direct the output files for each simulation into a separate folder on the hard disk. The user can change the output destination for a simulation by choosing the destination within the standard open-file dialogue (see example above) allowing the user to redirect the output of a simulation to a desired folder.

Create backup files:

If this option is selected in the *Files* dialogue, IMPACT will rename existing output files of the same name with a *.bak* suffix before generating new output files. This allows the user to keep the results of the last two simulations on disk without manually moving or renaming the files.

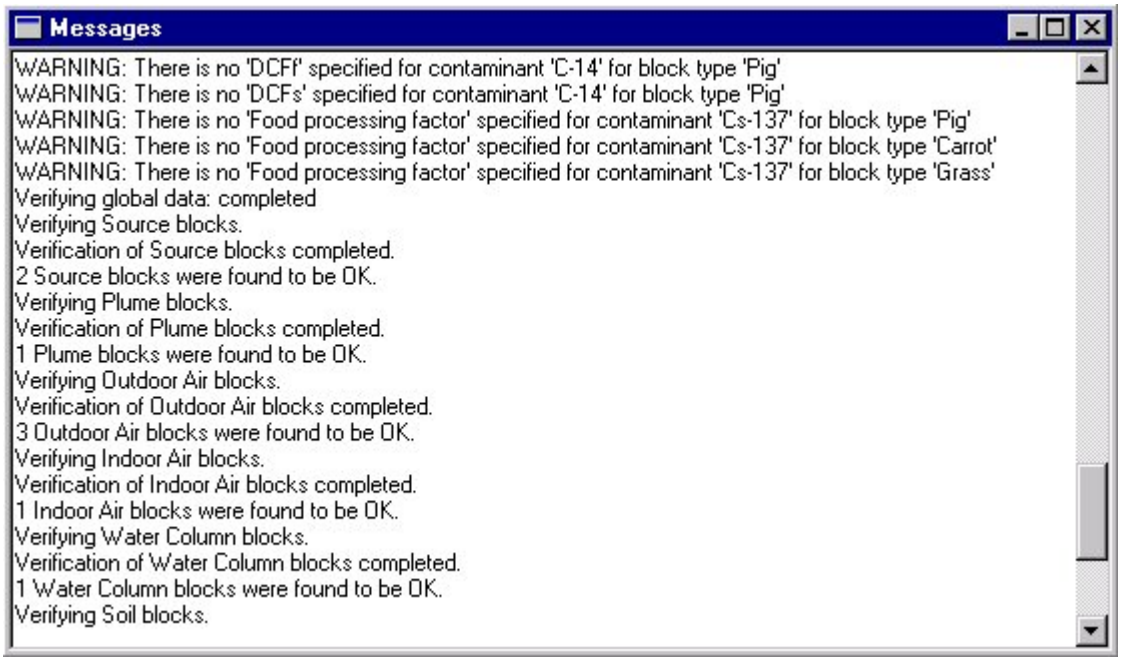
5.2 Verifying Attributes

Prior to running a simulation, it is advisable to verify the attributes in a scenario. This verification will tell the user if monitors have been linked correctly and will catch many other common mistakes that can lead to

errors during calculations. Verification is accomplished by selecting the **Verify** command from the **Simulate** menu.

When the user selects the **Verify** command, IMPACT checks the attributes (global and local) for each polygon and block and performs a quick "sanity" check to make sure that none of the values are unreasonable, such as a surface water depth of zero, or a negative contaminant molar mass.

Following completion of the verification process, the *Messages* window will appear notifying the user if one or more attributes are invalid (e.g. a *Soil* block with a density of zero), allowing the user to make appropriate changes to the scenario prior to running a simulation.



The contents of the *Messages* window can be selected and copied to the clipboard, where they are available for pasting to other software applications. This can be useful if a large number of verification errors are reported and the user want to keep a record of them.

IMPACT automatically performs a verification before running a simulation, but in this case the user will be unable to correct any errors before the simulation starts to run. For this reason, we recommend that the user perform a verification using the **Verify** command before running a simulation.

5.3 Specifying Simulation Attributes

To specify simulation attributes, select **Run**… from the **Simulate** menu. This opens the *Run* dialogue, as shown below. Here the user can specify the simulation's attributes, and select the monitors for creating files, graphs, and maps during the simulation.

5.3.1 Duration

This attribute indicates the total amount of time, in years, for which the user wishes the simulation to run. This parameter serves to specify Facility Lifetime. Several blocks include equations that differ depending on the simulation duration.

Note that the model begins simulating at time zero, so that a run with a duration of 10 years will actually run from year 0 to the end of year 10, with the time reported accordingly in all output files. The first time step represents the period from year 0 to the end of year 1, the second time step from year 1 to the end of year 2, and the final time step from year 9 to the end of year 10.

5.3.2 Time step

The simulation time step parameter indicates the length of each simulation time step, in years. In DRL mode, the simulation time step is essentially irrelevant. The monitoring time step parameter indicates the time interval, in years, between outputs.

5.3.3 Iterations

This parameter specifies the number of iterations to perform for probabilistic (Monte Carlo) simulations. For each iteration, any *parameter* attributes in the scenario are selected randomly based on the PDF defined for each parameter. These values are used for the current iteration, and the simulation results are calculated accordingly.

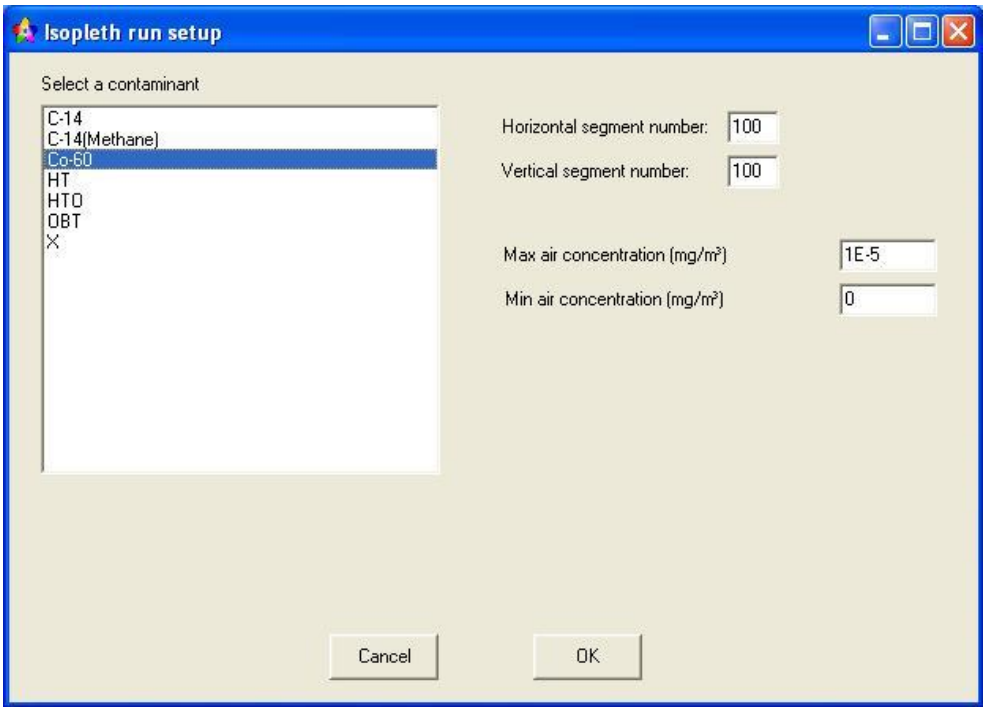
Running a simulation for one iteration with all parameters set to a *Constant* PDF is equivalent to running the simulation deterministically.

5.3.4 Files

The user can jump quickly to the *Files* dialogue by clicking the button. The total number of monitors that have been set to create file output is summarized beside the button.

5.3.5 Isopleth Run

Isopleth Run is a special run only taking account of air dispersion, assuming air sources are the only source type in the scenario. It doesn't produce any file outputs other than showing an on-screen isopleth map which is a colored map representing air concentrations. It can only take care of one contaminant at a time. In isopleth run mode, the entire map area is divided into grid squares which are defined in the isopleth run window shown below.



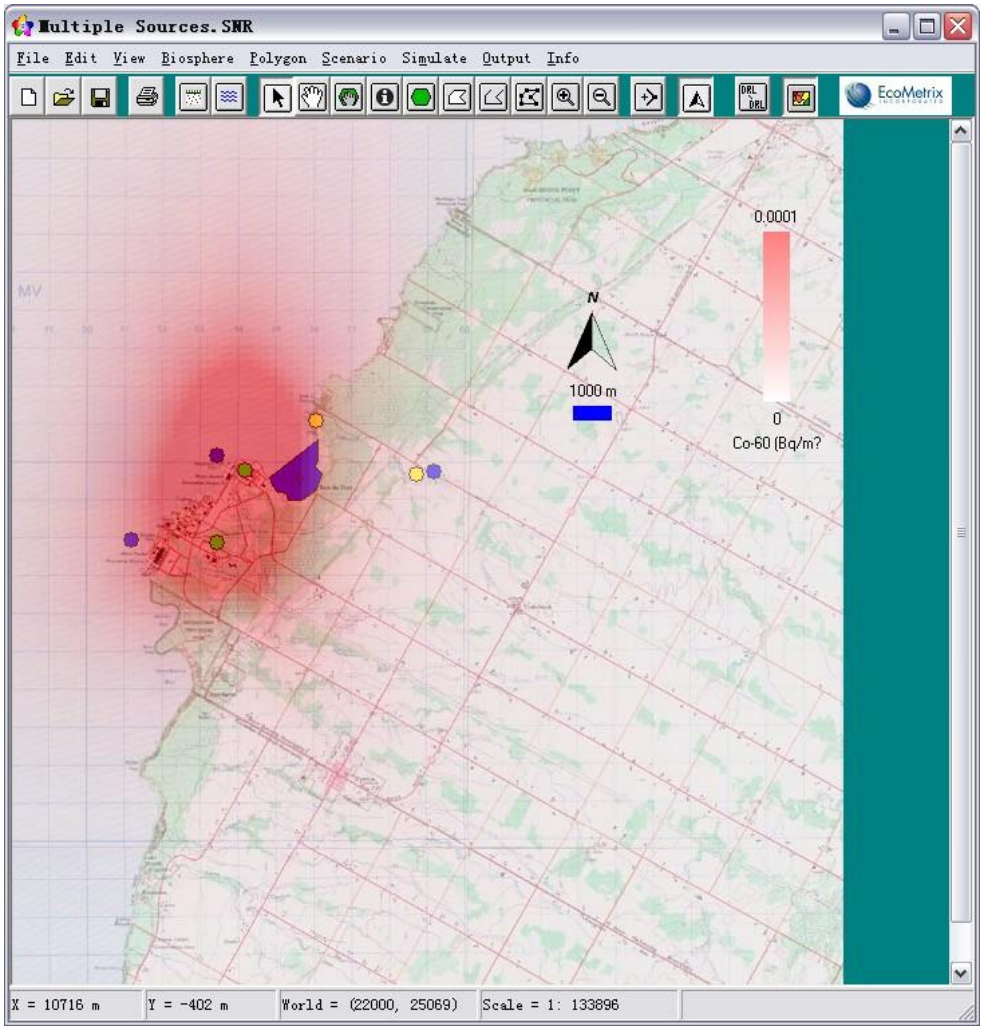
The grid is defined by the number of horizontal and vertical segments. Each grid square is assumed to be a land polygon containing an outdoor air block and a concentration monitor. The isopleth run only runs the air dispersion model to calculate the air concentration contributed by plumes in the map area. All other sources are ignored; it is assumed that no other sources present. The isopleth map is a colored image in which each grid filling color density is calculated by interpolating the air concentration between the user-specified maximum and minimum concentrations.

If more grid squares are defined, the smoother and sharper the isopleth is, but the down side is that longer run time and more memory will be required.

It is not always easy to find the proper maximum and minimum values to be able to see a colored isopleth map. A too large maximum value causes no color putting on the map while a too small maximum value

gives uniform heavy filling color density on the entire map, therefore spatial patterns can't be discerned from the isopleth map. It is suggested to run the scenario and check the air concentration range before switching to isopleth run mode, and then use that concentration range as a reference to set up proper maximum and minimum concentration values.

A successful isopleth map should look like this.



5.4 Running Simulations

When the user clicks the **OK** button in the *Run* dialogue, the simulation begins. A simulation is broken down into several phases:

For each simulation:

- a *start* phase when output files are created, and graph windows are opened

For each iteration:

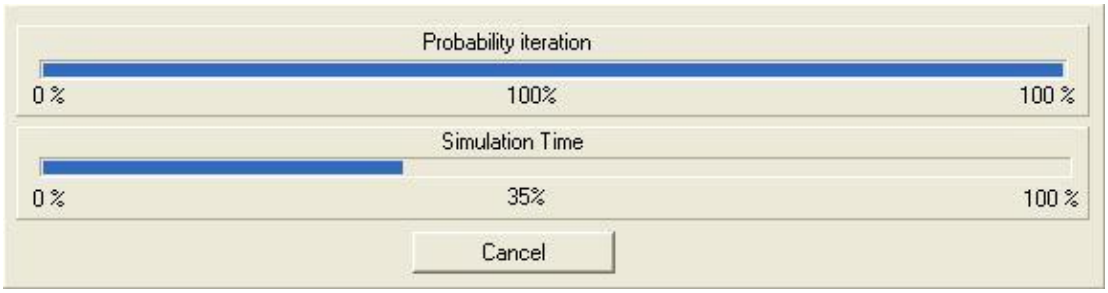
- an *initialization* phase when *Parameter* values are selected for the current iteration, based on their PDF's

For each time step:

- a *simulate* phase when each polygon and block performs their calculations based on inputs from other polygons and blocks that they are linked to
- an end *phase* when data are written to output files, and graphs and maps are updated

- a *finish* phase when output files are closed

At the onset of initialization, the *Messages* window will be shown where the status of the simulation and any error messages are posted. During initialization, a series of cautions will appear regarding probabilistic simulation requirements and DRL requirements. Once initialization is complete (assuming no problems exist in the scenario) and the simulation begins, a status bar will appear, depicting simulation progress.



The user is finally prompted when the simulation is complete and all output files are written and saved.

5.5 Examining Results

After a simulation is complete, the user can examine the results of the simulation to see what effect the contaminant releases have had on the biosphere represented in the scenario. Some results are available from within IMPACT, while others must be viewed with separate software.

5.5.1 Working with Files

The files created by IMPACT during a simulation are standard tab-delimited ASCII (text) files that can be opened with most word processor, spreadsheet or graphing programs. There are a few things to keep in mind when using these files with other programs.

Output files have a five line header that contains information such as when the file was created. If the user wants to import these files into a graphing program such as DeltaGraph® Pro or KaleidaGraph™, the user will need to delete the first five lines from the file.

Microsoft® Excel has a defined column limit that may cause problems when importing files created by *Dose/Risk* monitors. Depending on the number of contaminants and pathways specified in one of these monitors, the output file it creates may contain more than the upper limit of columns, although this is unlikely. The solution in this case is to break the contaminants and pathways up into several *Dose/Risk*

monitors so that the total number of columns (number of contaminants × number of pathways) is less than the spreadsheet column limit for each output file produced.

IMPACT cannot open its own output files. Double-clicking on an output file will open it automatically in Microsoft® Excel.

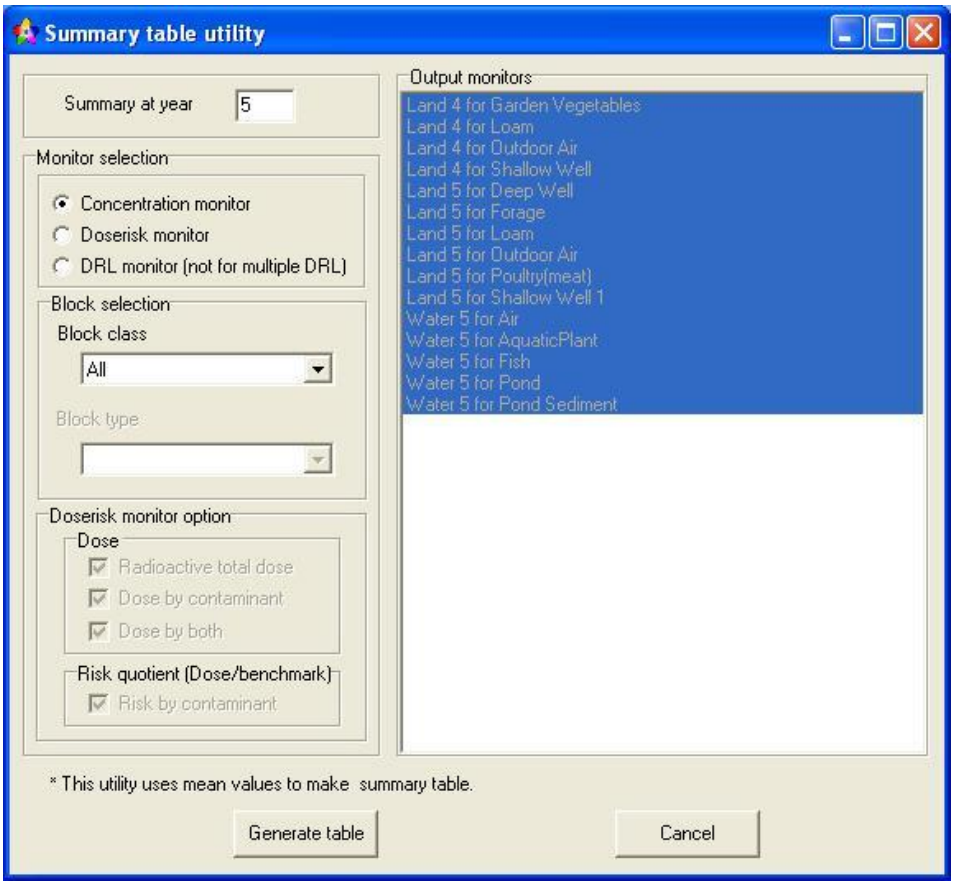
5.5.2 Summary Tables

IMPACT has a Summary Table feature, which allows the user to summarize outputs from multiple monitors in a single output file after a run completes. The monitors to be summarized would each reflect a separate receptor.

This feature is accessible by clicking the **Summary table utility (fixed style)** command or **Summary table utility (style options)** command from the **Output** menu in the main window after the scenario runs. These commands activate dialogues, examples of which are presented below.

Summary table utility (fixed style)

Summary table utility (fixed style) summarizes the latest run results and makes a summary table as the user specified. The styles are fixed to produce all raw output data cross all monitors on a certain pattern that is: concentration by contaminant, dose by contaminant, or dose by both contaminant and pathway. These fixed style summary files have the least formatting and they are good for further data processing. The summarized tables are output to excel files as the user specified. When the product of the contaminant number and the pathway number is bigger than 256, office excel 2003 and earlier versions can't handle the data by contaminant and by pathway.

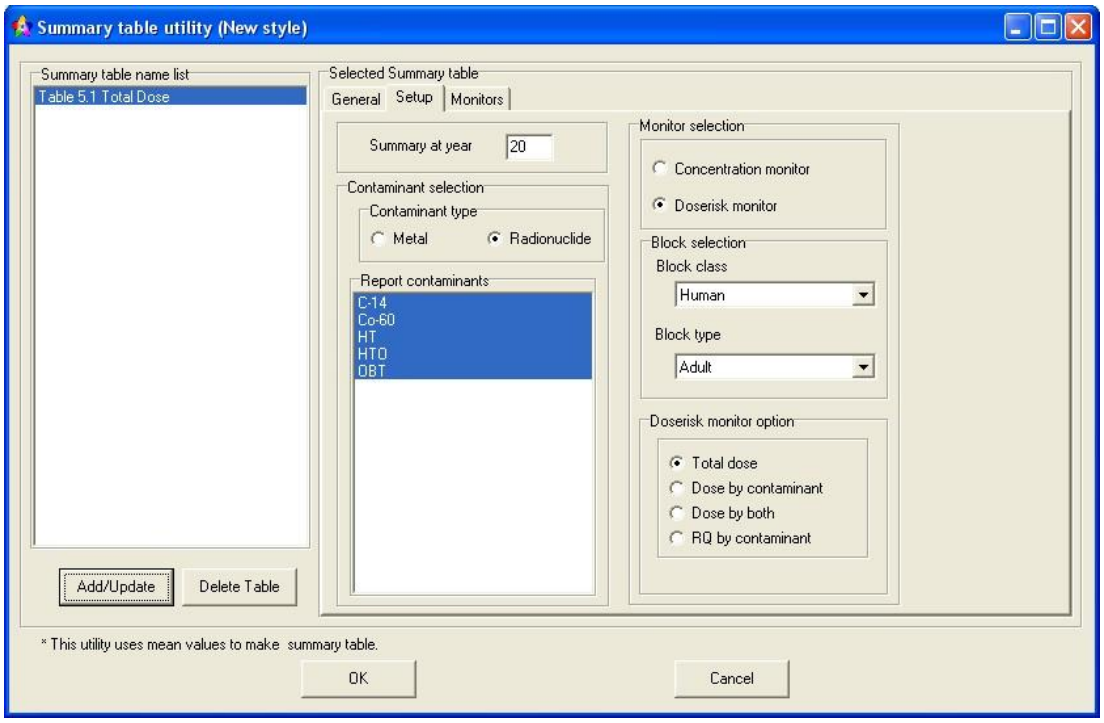


The creation of summary tables requires the specification of monitors for output file production. Only monitor files will appear in the *Output monitors* list appearing in the dialogue. Depending on the manner in which the monitors have been configured, the Summary Tables function will allow compilation of output reflecting one of three options. In the example above, all Concentration monitors have been selected as the information to appear in the summary Table. The resulting Table provides the requested endpoint from the selected monitors, representing only the final time step of the simulation.

Summary table parameters defined in the summary table window are parts of the scenario, and thus will be saved within the scenario file when the scenario is saved. The defined summary tables will be generated automatically next time when the scenario runs, as will the monitor file outputs.

Summary table utility (style options)

Summary table utility (style options) summarizes the latest run results and makes a summary table as the user specified. It is more flexible as to output formats. It is used to produce final report tables. The summary table settings are saved as parts of the scenario and the saved summary tables get updated when the scenario completes its run. An example of a summary table setting is shown as follows.

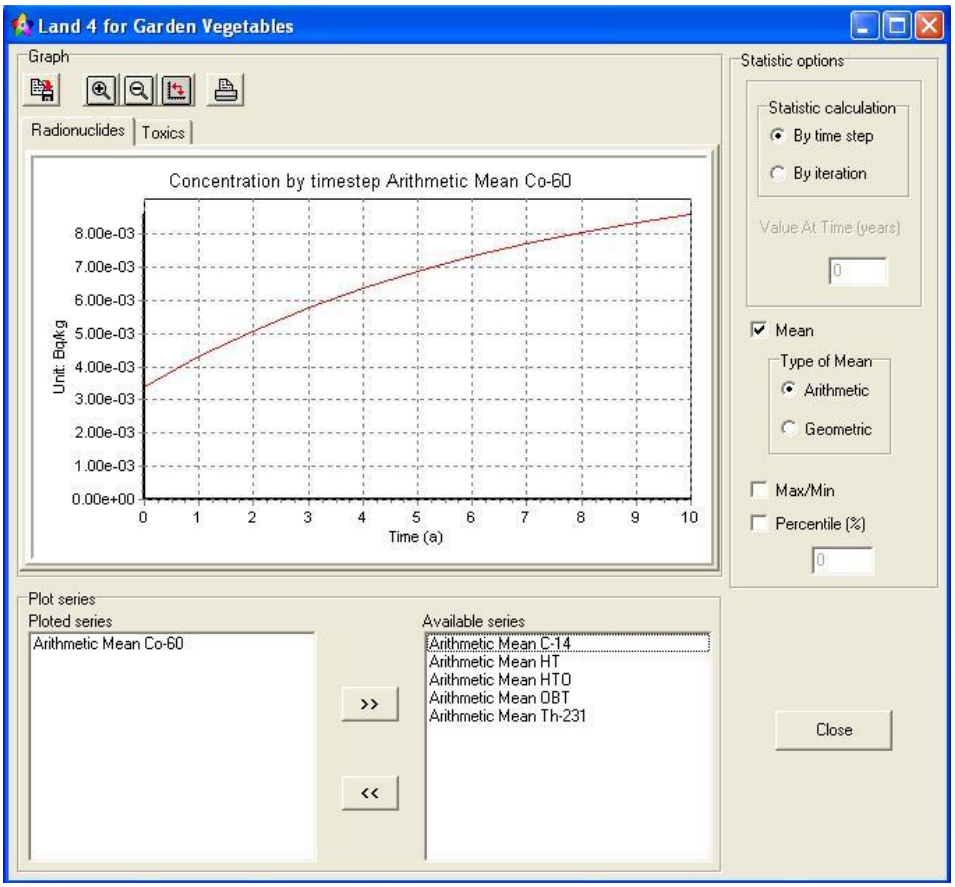


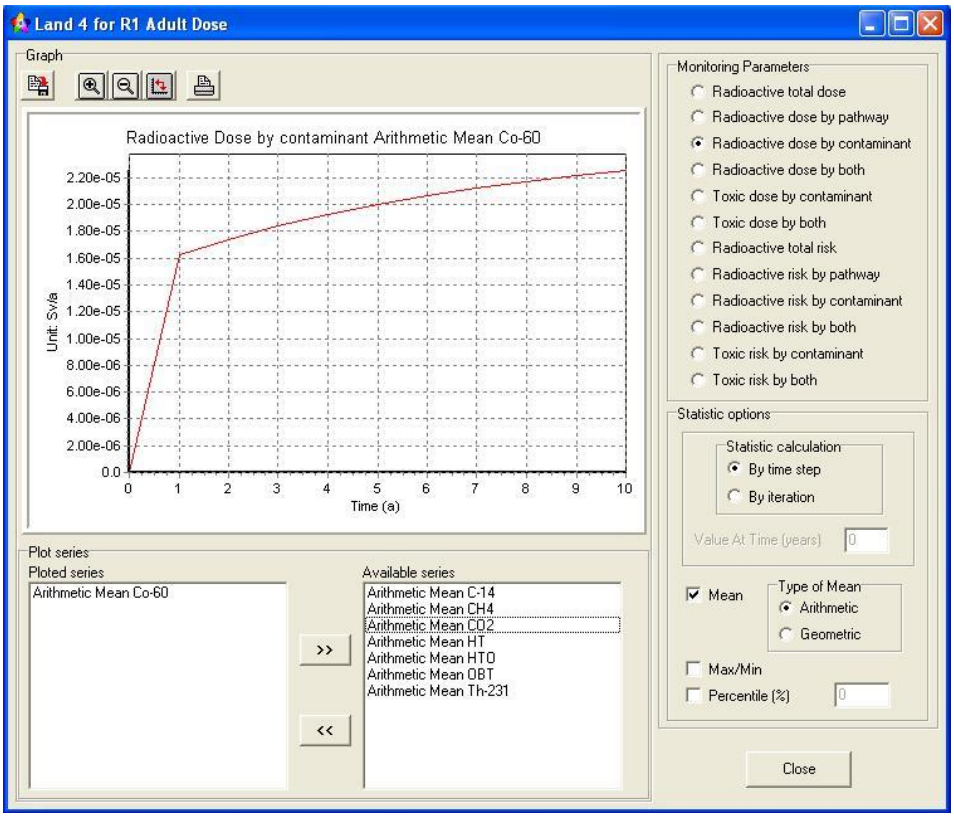
5.5.3 Graphic Analyses

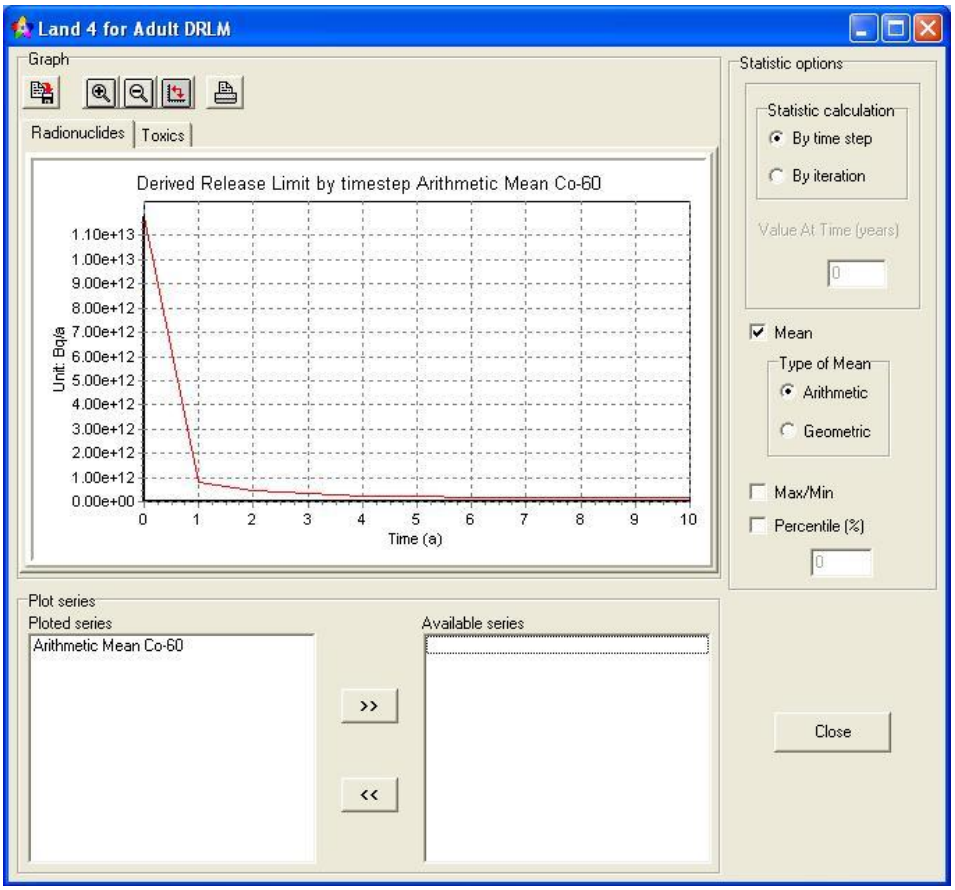
Similar to the summary tables feature, **Graphic Analyses** is a post process function which is accessible after a run is completed and output data for all monitors are ready to use. **Graphic Analyses** doesn't produce file outputs but it provides a way to plot data in many various ways, and it gives an option to save the plotted graph to image format.

Graphic Analyses is accessible by clicking the **Graphic Analyses** command from the **Output** menu in the main window after the scenario runs. This command opens a Select Monitor window shown below.

A user can only select one monitor to do the graphic analyses at a time. Once a monitor gets selected, a monitor graphic analyses window will be opened. Concentration monitors, Dose/Risk monitors and DRL monitors have different windows to customize the production of graphs. The graphic analyses windows for a concentration monitor, a Dose/Risk monitor and a DRL monitor are shown as follows.


Land 4 for Garden Vegetables
Graph
Radionuclides
Toxics
Concentration by timestep Arithmetic Mean Co-60
8.00e-03
7.00e-03
6.00e-03
5.00e-03
4.00e-03
3.00e-03
2.00e-03
1.00e-03
0.00e+00
Unit: Bq/kg
0 1 2 3 4 5 6 7 8 9 10
Time (a)
Statistic options
Statistic calculation
By time step
By iteration
Value At Time (years)
0
Mean
Type of Mean
Arithmetic
Geometric
Max/Min
Percentile (%)
0
Plot series
Ploted series
Arithmetic Mean Co-60
>>
<<
Available series
Arithmetic Mean C-14
Arithmetic Mean HT
Arithmetic Mean HTO
Arithmetic Mean OBT
Arithmetic Mean Th-231
Close


Land 4 for R1 Adult Dose
Graph
Radioactive Dose by contaminant Arithmetic Mean Co-60
Unit: Sv/a
Time (a)
Plot series
Ploted series
Arithmetic Mean Co-60
Available series
Arithmetic Mean C-14
Arithmetic Mean CH4
Arithmetic Mean CO2
Arithmetic Mean HT
Arithmetic Mean HTO
Arithmetic Mean OBT
Arithmetic Mean Th-231
>>
<<
Monitoring Parameters
Radioactive total dose
Radioactive dose by pathway
Radioactive dose by contaminant
Radioactive dose by both
Toxic dose by contaminant
Toxic dose by both
Radioactive total risk
Radioactive risk by pathway
Radioactive risk by contaminant
Radioactive risk by both
Toxic risk by contaminant
Toxic risk by both
Statistic options
Statistic calculation
By time step
By iteration
Value At Time (years)
Mean
Type of Mean
Arithmetic
Geometric
Max/Min
Percentile (%)
Close



Graphic Analyses windows are not saved when the user saves a scenario, so their contents are lost when the user quits IMPACT or runs another simulation. The user can, however, print the graph simply by selecting the Print command and clicking the save-to-file command button while the *Graph* window is open.

Components in the *Graphic Analyses* window

Graph

The graph group box has a graph area and some utility buttons on the top part. The graphs are shown in the graph area and the utility buttons help viewing and manipulating the graphs shown in the graph area.

The graph area has two pages representing two categories: *Radionuclides* and *Toxics*. The contaminant type user-specified in the database determines which page the contaminant data should be plotted in. The two graphs use different units.

The top part utility buttons are save, print, zoom in/out and auto scale buttons. Using these buttons can give the best view of the data.

Monitoring Parameters and *Statistic options*

As described in monitor setup (section 4), the same information needs to be put in the graphic analyses monitor for monitoring parameters and statistical options.

The user can graph data either by time step or by iteration, depending on the statistics options specified. When plotting by time step, the X-axis will display time in units of years [a]. When plotting by iteration, the X-axis will simply display the iteration number [#]. In either case, the configuration and units of the Y-axis units will depend on the type of monitor that is used for the graph. For example, the Y-axis units for a concentration monitor could be [mg/kg] or [Bq/L] depending on the contaminant type and the type of block to which the monitor is linked.

Plot Series

Plot Series shows all available data series as specified in *Monitoring Parameters* and *Statistic options*. Once the *Monitoring Parameters* and *Statistic options* information is input, the available data series will appear in *Available Series* list box. Multiple selections of data series from *Available Series* can be done by holding the Ctrl key and left-clicking the series names. Then those selected series data can be added to *Plotted Series* list box by clicking "<<" or double clicking one of the selected series name. Once the series are added to the *Plotted Series* list box, the series will be drawn in the graphs.

Changing a Graph's Display

The user can change a graph's format by clicking on one of the three formatting buttons in the *Graph* window's toolbar.

IMPACT has been designed to allow for the representation of virtually all reasonable pathways of contaminant transport and exposure. The various model equations and input parameters have been established to represent these pathways in as direct a manner as possible. However, the vast variability of real world situations is such that some scenarios may involve exposure pathways that are not directly or intuitively accommodated by the standard methods available in IMPACT. Section 6 identifies some such instances and describes the special manner in which IMPACT can be applied for these special cases

SPECIAL CASES

6.1 Honey

The DRL Guidance Document (EcoMetrix, 2008) provides equations for the transfer of radionuclides from plants to honey, which can subsequently be ingested by humans. These equations are not directly included in IMPACT, and the transfer from plant materials to honey is handled through selective parameterization of "honey bees", which are established as a "terrestrial animal", and use of the routine animal ingestion model to determine radionuclide levels in the animal product (i.e., in the honey). Attributes of the honey bee are set so that forage plant ingestion is the only non-zero pathway of radionuclide uptake (i.e. inhalation and all ingestion rates except plant ingestion are set to zero). The equations defining plant ingestion transfer for animals become the only functioning equations. The parameterization for these equations is set such that the result is equal to the plant to human CR_h value (dw) divided by the dry weight fraction of forage (DW_p).

The recommended parameterization of the "Honey Bee" terrestrial animal block is as follows:

- Air intake - set at 0
- Soil intake -- set at 0
- Water intake - set at 0
- Plant intake - set at 1 kg/day
- Animal intake - set at 0
- Aquatic plant intake - set at 0
- Aquatic animal intake - set at 0
- Body mass (Not Applicable to DRL calculation)
- Water occupancy factor (Not Applicable to DRL calculation)
- Water Intake Fraction Obtained from Drinking - set at 0
- Water Intake Fraction Obtained from Plant Feed - set at 5.263.
- Water Intake Fraction Obtained from Decomposition - set at 0
- Water Equivalent of Dry Matter - set equal plant Water Equivalent of Dry Matter (0.56)
- Isotopic Discrimination Factor - set equal plant Isotopic Discrimination Factor (0.8)
- Dry/Fresh Weight Ratio - set to equal plant dry/fresh weight ratio (0.19)
- Ingestion transfer factor - set to the defined plant-to-honey CR_h value (dry weight basis)
- Inhalation transfer factor - not applicable - set all to zero

It is noted that the value for Water Intake Fraction from Plant Feed may exceed the logical constraint (i.e. these values in theory should not exceed 1). In this case, the Verify warning about a parameter out of range should be ignored.

The CSA standard doesn't specifically address OBT transport from plant to honey. The parameters above will give an OBT transfer factor of 5.263.

6.2 Breast Milk

The ingestion of breast milk has been identified as a potential exposure pathway that may require consideration in the calculation of DRLs. The DRL Guidance (EcoMetrix/COG, 2008) includes detailed methodology and default data to model the dose to a nursing infant.

Human-to-human links are not definable in IMPACT. Accordingly, the ingestion of breast milk is accommodated in IMPACT through the use of a Terrestrial Animal Block and selective parameterization to represent transfer to mother's milk. The following table outlines the relevant pathways.

Breast Milk Transfer Processes

Transfer Parameter	Compartments		Parameter Units
	From	To	
$P(i)_{19m}$	Atmosphere (inhalation)	Mother's milk	$m^3 * L^{-1}$
$P(i)_{29m}$	Surface water (ingestion)	Mother's milk	L (water) $* L^{-1}$ (milk)
$P(e)_{29m}$	Surface water (^3H immersion)	Mother's milk	L (water) $* L^{-1}$ (milk)
$P(i)_{39m}$	Soil (incidental ingestion)	Mother's milk	$kg * L^{-1}$
P_{49m}	Forage and crops (ingestion)	Mother's milk	$kg * L^{-1}$
P_{59m}	Animal produce (ingestion)	Mother's milk	$kg * L^{-1}$
P_{69m}	Aquatic animals (fish ingestion)	Mother's milk	$kg * L^{-1}$
	Sediment (incidental ingestion)	Mother's milk	$kg * L^{-1}$
$P(i)_{89m}$	Mother's milk		
P_{9m9}		Infant dose	$Sv * a^{-1} * Bq^{-1} * L$

To parameterize the terrestrial animal equations to represent transfer to mother's milk, the following parameter substitutions are required:

- The animal transfer factors for Inhalation (F_{inh}) and ingestion (F_{ing}) in units of d/kg should be replaced with mother's milk transfer factors in units of d/L;

- The animal intake rates for air (m^3/d) and water (L/d) should be replaced by mother's intake rates in the same units; the rates may be adjusted for occupancy factors or water processing factors as appropriate, since these factors are not in the animal equations;
- The animal soil/sediment intake rate (kg/d) should be replaced by the mother's incidental soil/sediment intake rates in the same units; the latter may be adjusted for exposure frequency factors as appropriate, since these factors are not in the animal equations;
- The animal feed intake rates (kg/d) should be replaced by the mother's food intake rates in the same units; the latter may be adjusted for food processing factors as appropriate, since these factors are not in the animal equations.

The specific activity equations for tritium in animal milk differ from the mother's milk equations involving transfer factors in the DRL Guidance (EcoMetrix/COG, 2008). In order to use the transfer factor approach for mother's milk, transfer factors may be obtained from Appendix A30 of the COG DRL Guidance. Alternatively, the specific activity model for tritium in animal milk may be considered to represent mother's milk, using a DW_p value appropriate to the fruits and vegetables consumed.

The air and water contribution of C-14 to animal milk are considered to be negligible relative to feed contributions, and are set to zero. This is probably a reasonable approach for mother's milk also. However, it should be noted that the transfer factor approach in the DRL Guidance (EcoMetrix/COG, 2008) includes air and water contributions.

REFERENCES

EcoMetrix/COG. 2008. Guidance for Calculation of Derived Release Limits for Radionuclides in Airborne and Liquid Effluents from COG Member Facilities. Prepared for: The CANDU Owners Group Inc. Ref; 04-1103. June 2008

Canadian Standards Association (CSA). 2008. Guidelines for calculating derived release limits for radioactive material in airborne and liquid effluents for normal operation of nuclear facilities. CSA standard N288.1-08. September 2008

APPENDIX

A.1 Units of Operation

In all equations, regardless of origin, the code uses units consistent with international standards for all parameters, as follows:

Length, area, volume – meters (m, m^2, m^3),

Time – seconds (s),

Mass – kilograms (kg),

Temperature - ^{o}Centigrade (^{o}C),

Activity – Becquerels (Bq), and

Dose – sieverts (Sv).

All calculations are completed following conversion (if required) of initial parameter units to the standard units identified above. Units of Input for all IMPACT parameters are identified.

A.2 Meteorological Considerations

In a scenario with a variety of polygon types and land uses, you must calculate an average surface roughness factor that describes the typical surface that the plume travels over from the release point to the receptor(s).

Surface or Land Use:	**Surface Roughness Factor (Z_0):**
Lawn grass, bodies of water	1
Plowed land	4
Open grassland	10
Rural areas with mixed farming, woods, small villages	40
Cities and forests	100
Cities with tall buildings	400

Coefficients of the function $g_i(x)$ used in calculating σ_{zi} are summarized in the following table:

Stability	**Coefficients**			
Category (i)	**a_1**	**b_1**	**a_2**	**b_2**
A (i=1)	0.112	1.06	5.38e-4	0.815
B (i=2)	0.130	0.950	6.52e-4	0.750
C (i=3)	0.112	0.920	9.05e-4	0.718
D (i=4)	0.098	0.889	1.35e-3	0.688
E (i=5)	0.0609	0.895	1.96e-3	0.684
F (i=6)	0.0638	0.783	1.36e-3	0.672

Coefficients of the function $F(Z_0,x)$ used in calculating σ_{zi} are summarized in the following table:

Roughness	**Coefficients**			
Length Z_o [cm]	**c_1**	**d_1**	**c_2**	**d_2**
1	1.56	0.0480	6.25e-4	0.45
4	2.02	0.0269	7.76e-4	0.37
10	e*	0	0	0
40	5.16	-0.098	18.6	-0.225
100	7.37	-0.0957	4.29e3	-0.60
400	11.7	-0.128	4.59e4	-0.78

*e = base of natural logarithms ~ 2.71828

The meteorological data required for IMPACT is triple-joint frequency data, as output from the *STAR* computer program. Any number of years of annual meteorological data can be input from a tab-delimited text file. If more than one year of annual data is included in the file, then IMPACT will randomly select a single year's data for each iteration during a probabilistic simulation. If you want to include more than one year's data in a deterministic simulation (i.e. only one iteration) then you should average your data set before importing it.

STAR data are input in the *Meteorology* dialog, which is accessed from the **Biosphere** menu. The wind rose diagram in the dialog can display various combinations of the STAR data by changing the controls in the dialog, as briefly described in Section 3.6.3.

Triple-joint frequency data are stored in ASCII (text) files that are tab-delimited with return characters at the end of a line, such as those produced by most spreadsheet and word-processor programs. The first line in the file should be an integer specifying the number of years of data contained in the file. The second line is not read by IMPACT and can be used for comments. The example below includes a comment line identifying the content and required format of the 3rd line. The third line specifies the representative velocities for each of the 6 velocity classes (formatted as noted in Line 2). The remainder of the file is composed of lines of STAR data, in the following format:

`sector ⇒ stability class ⇒ f1 ⇒ f2 ⇒ f3 ⇒ f4 ⇒ f5 ⇒ f6↵`

where ⇒ = TAB, ↵ = RETURN, sector = 1 of 16 compass sectors (e.g. N, SW, ENE), stability class = one of six letter codes (A to F), and f1 through f6 are wind frequency data for wind speed classes 1 through 6 respectively.

The data contained in the first two columns (sector and stability class) are ignored, and can be any alpha-numeric symbol. The order in which sectors and stability classes are listed in the file must be as shown in the example above (i.e. N to NNW, A to E). A complete data set for one year of annual data contains 96 lines (6 stability classes x 16 sectors). If the meteorological data are calculated more frequently than annually, they should be averaged to produce an annual data set.

A sample data set containing a single year's data would look like this:

```
1
Wind Speed Default Values (6 values for 6 classes from lower to higher, Tab
delimited, No space before values)
0.5⇒       1.5⇒      3.5⇒       6.5⇒         9⇒        11↵
N⇒    A⇒    0.0023⇒   0.0105⇒   0.021⇒    0.0105⇒   0⇒        0↵
NNE⇒  A⇒    0⇒        0.0046⇒   0.0035⇒   0.0011⇒   0⇒        0↵
NE⇒   A⇒    0.0011⇒   0.0011⇒   0.0011⇒   0.0023⇒   0⇒        0.0082↵
ENE⇒  A⇒    0.0058⇒   0.0011⇒   0.0046⇒   0.0035⇒   0⇒        0↵
E⇒    A⇒    0.0035⇒   0.0093⇒   0.0058⇒   0.0046⇒   0.0011⇒   0↵
ESE⇒  A⇒    0.0035⇒   0.007⇒    0.0082⇒   0.007⇒    0⇒        0↵
SE⇒   A⇒    0.0046⇒   0.0035⇒   0.0023⇒   0.0046⇒   0⇒        0↵
SSE⇒  A⇒    0.007⇒    0.0082⇒   0.0093⇒   0.0058⇒   0.0011⇒   0↵
S⇒    A⇒    0.0093⇒   0.0339⇒   0.0269⇒   0.0175⇒   0⇒        0↵
SSW⇒  A⇒    0.0023⇒   0.0175⇒   0.0327⇒   0.0105⇒   0.0023⇒   0↵
SW⇒   A⇒    0.0035⇒   0.0187⇒   0.0128⇒   0.0023⇒   0⇒        0↵
WSW⇒  A⇒    0.0058⇒   0.0199⇒   0.0304⇒   0.0023⇒   0⇒        0↵
W⇒    A⇒    0.014⇒    0.0409⇒   0.0421⇒   0.0222⇒   0.0023⇒   0↵
WNW⇒  A⇒    0.0035⇒   0.0175⇒   0.0222⇒   0.0046⇒   0.0058⇒   0.00468↵
NW⇒   A⇒    0.0058⇒   0.014⇒    0.0281⇒   0.0105⇒   0.0082⇒   0↵
NNW⇒  A⇒    0.0199⇒   0.0082⇒   0.0281⇒   0.0175⇒   0.0046⇒   0↵
N⇒    B⇒    0.0023⇒   0.0105⇒   0.021⇒    0.0105⇒   0⇒        0↵
NNE⇒  B⇒    0⇒        0.0046⇒   0.0035⇒   0.0011⇒   0⇒        0↵
NE⇒   B⇒    0.0011⇒   0.0011⇒   0.0011⇒   0.0023⇒   0⇒        0.0082↵
…
WNW⇒  F⇒    0.0035⇒   0.0175⇒   0.0222⇒   0.0046⇒   0.0058⇒   0.00468↵
NW⇒   F⇒    0.0058⇒   0.014⇒    0.0281⇒   0.0105⇒   0.0082⇒   0↵
NNW⇒  F⇒    0.0199⇒   0.0082⇒   0.0281⇒   0.0175⇒   0.0046⇒   0↵
```

A.3 Effective and Non-Stochastic Dose Calculations

IMPACT calculates radiation doses as effective doses for most human receptor types. An effective dose is a whole-body equivalent dose which incorporated potential effects on all organs and tissues in the body. the effects of interest are cancer induction or hereditary effects, also known as stochastic effects.

IMPACT also has the capability of calculating radiation doses to specific body tissues (known as non-stochastic doses).

Whether IMPACT calculates an effective or non-stochastic dose depends on the DCFs that are entered in the database. If you are interested in calculating doses to specific organs, you should enter the organ-specific dose conversion factor in the database and indicate the organ for which the DCF applies in the reference or note for that DCF. If you are interested in an effective dose, enter the appropriate effective DCFs in the database.

IMPACT includes a "skin" human as a default receptor type which can be used in calculating skin dose. The external DCF values for this receptor should be those for skin dose rather than effective dose.

Dose to tissues other than skin can be obtained in similar fashion, by creating a special human receptor type, and using appropriate DCF values. However, doses to tissues other than skin are not limiting for any radionuclides, and in practice should not be needed.